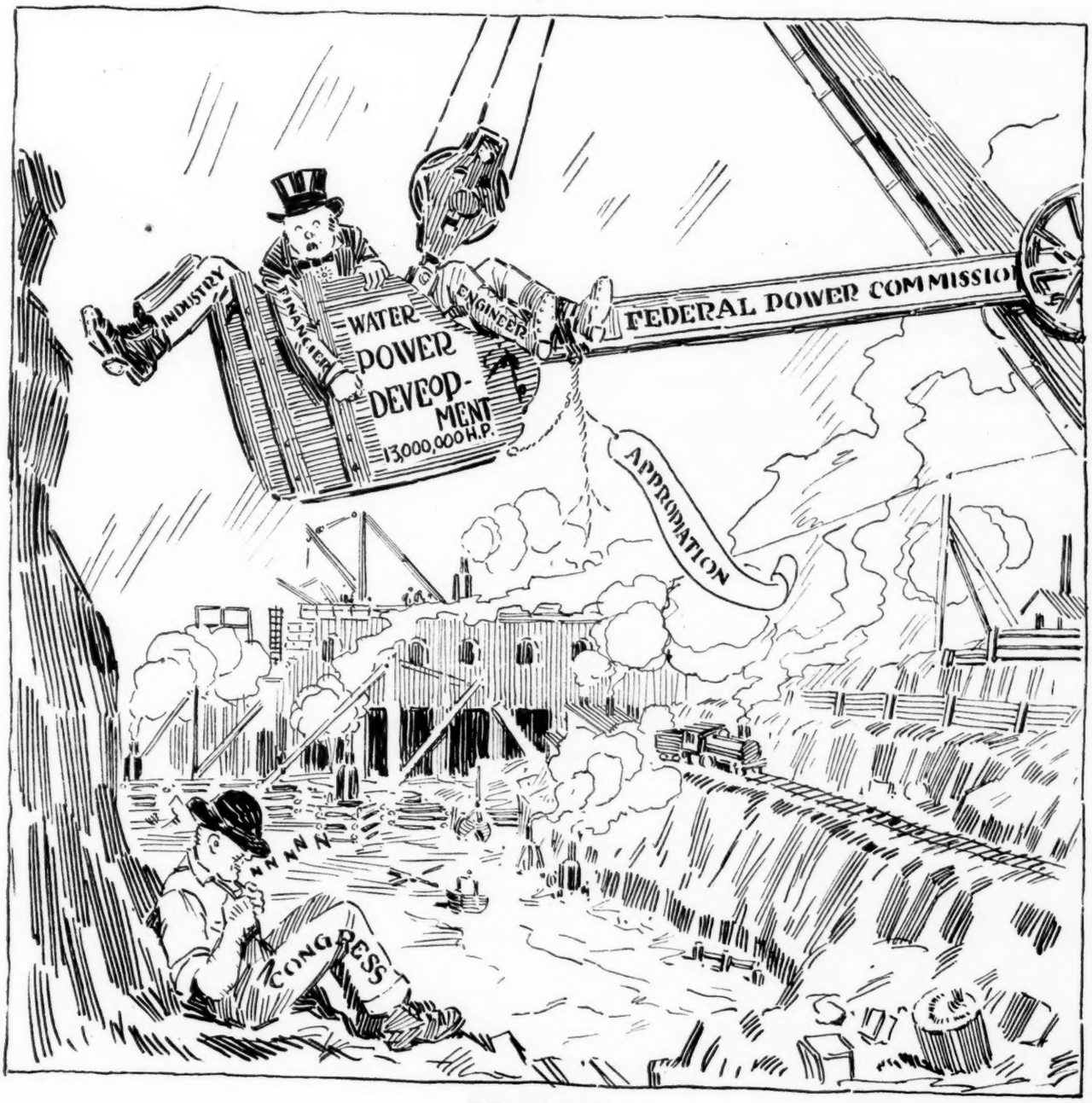
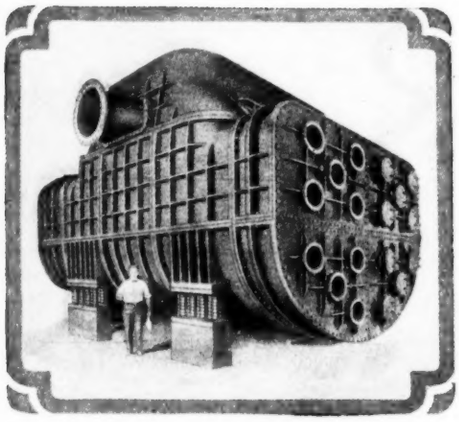
# POWER

*Volume* 53 New York, March 15, 1921 *Number* 11




**Held Up**

*Contributed by C. H. Bromley*



# TEST RESULTS OF A 50,000 SQUARE-FOOT SURFACE CONDENSER

DURING the year 1919 the New York Edison Co. installed two 35,000-kw. turbo-generators at its Waterside Station No. 1. These units were designed for 250 lb. gage boiler pressure with 200 deg. F. superheat, and to give their highest efficiency under a load of 25,000 kw. The necessary changes to the boiler equipment not having yet been made, they are being operated with steam at 200 lb. gage and 100 deg. superheat, under which conditions the steam consumption with a load of 25,000 kw. is stated by the maker to be 300,000 lb. per hour. The steam consumption is, of course, influenced by the vacuum, probably decreasing about 6 per cent when the vacuum is raised from 29 to 29.5 in., referred to a 30-in. barometer.

Each turbine exhausts into a surface condenser located directly beneath the turbine and mounted on spring supports. Each condenser contains 50,000 sq.ft. of 11-in. outside diameter. No. 18 B.w.g. Admiralty tubes, 19 ft. long between tube plates. The circulating water, which is supplied by a 54-in. bi-rotor circulating pump designed to deliver 70,000 gallons per minute driven by a geared turbine, makes two passes through the condenser. In regular operation air is removed by a turbine-driven turbo air pump and condensate by two centrifugal turbine-driven hotwell pumps. As a spare there is also a steam-jet air pump.

The performance of this exceptionally large condenser has been carefully studied, readings being made each hour for nine hours on nearly every day for two months. As an example, the following observations taken on the day showing the coldest circulating water, are quoted:

| Time | Hotwell Temperature | Inlet Temperature | Outlet Temperature | Barometer In. Hg. | Vacuum at Air Pump | Vacuum at Turbine | Load Kw. |
|---|---|---|---|---|---|---|---|
| 8 | 47 | 33 | 43 | 30.70 | 30.15 | 30.10 | 25,000 |
| 9 | 47 | 34 | 43 | 30.70 | 30.15 | 30.10 | 25,000 |
| 10 | 46 | 32 | 42 | 30.72 | 30.15 | 30.10 | 25,000 |
| 11 | 46 | 32 | 42 | 30.71 | 30.15 | 30.10 | 25,000 |
| 12 | 46 | 33 | 42 | 30.67 | 30.15 | 30.10 | 25,000 |
| 1 | 48 | 34 | 44 | 30.64 | 30.15 | 30.10 | 25,000 |
| 2 | 48 | 34 | 44 | 30.59 | 30.10 | 30.00 | 25,000 |
| 3 | 49 | 35 | 44 | 30.57 | 30.10 | 30.00 | 25,000 |
| 4 | 48 | 34 | 44 | 30.57 | 30.10 | 30.00 | 25,000 |

Taking average values, we have:

| | |
|---|---|
| Hotwell temperature, deg. F. | 47.2 |
| Circulating water at entrance, deg. F. | 33.4 |
| Circulating water at outlet, deg. F. | 43.1 |
| Absolute pressure at air pump, in hg. | 0.52 |
| Absolute pressure at turbine exhaust, in hg. | 0.597 |
| Drop in vacuum through the condenser, in hg. | 0.072 |

While exceptionally cold circulating water is favorable to high vacuum, it does not encourage good values for pressure drop due to friction, nor for the coefficient of transmission as expressed in B.t.u. per square foot per hour per degree difference in temperature between water and steam. There are two ways in common use for figuring the coefficient of transmission, which, under certain circumstances, give widely different results, as will be illustrated later. For the present the simpler arithmetical formula will be used.

The total heat in each pound of steam exhausted from turbine consuming 12 lb. per kw.-hr. of steam at 200 lb. gage pressure and 100 deg. F. superheat would be 953.8 B.t.u. above condensate at 47.2 deg. F. From the 300,000 lb. of steam per hour there would, therefore, have to be extracted 286,000,000 B.t.u. The mean circulating-water temperature is 38.2 deg. F., and the temperature corresponding to an absolute pressure of 0.597 in. of mercury at the turbine exhaust is 63.35 deg. F., giving a mean temperature difference of 25.1 deg. Dividing 286,000,000 by 50,000 times 25.1 gives 228 B.t.u. as the transmission per hour per square foot per degree mean difference in temperature.

### Effect of Warmer Circulating Water

At this high vacuum the specific volume of the steam is very great—over 1,060 cu.ft. per lb. It cannot, therefore, penetrate very far into the tube bank without a considerable pressure drop and all of it must be condensed in a short distance, which is possible because of the relatively great difference in temperature between the steam and the exceptionally cold circulating water. It is of interest to observe, however, what happens with warmer circulating water, for which purpose we will take the results obtained on Dec. 2, when the water was the warmest for the period of the observations, varying from 48 to 50 deg. at the inlet, and 56 to 58 deg. at the discharge, the hourly absolute pressures at the turbine exhaust running 0.61, 0.60, 0.65, 0.66, 0.63, 0.64, 0.66, 0.66 and 0.65 in. mercury. At 9 a.m. the temperature of the entering circulating water was 50 deg. F., of the outgoing circulating water 58 deg F., and of the condensate 62 deg. F., giving 282,000,000 B.t.u. to be transmitted per hour.

The absolute pressure in the condenser of 0.60 in. corresponds to a steam temperature of 63.95 deg. F. The mean circulating-water temperature is 54, and therefore, according to the arithmetical method of computation the coefficient of transmission is 552 B.t.u. per square foot per hour per degree mean difference in temperature.

The arithmetical method, however, is based on the assumption that the temperature of the water rises uniformly in passing over the heat-transmitting surface, as shown by the accompanying diagram. That this cannot be true is self-evident from the fact that the heat transmission must be greater, and therefore the

rise in temperature more rapid, where the temperature difference is greater.

If it is assumed that throughout a given heat-absorbing surface the steam is at the initial temperature and the transmission is proportional to the temperature difference, the mean temperature difference is given by the formula,

$$d = \frac{\textit{inlet-water temperature minus outlet temp.}}{\textit{natural log.}\left(\frac{\textit{steam temp.} - \textit{inlet temp.}}{\textit{steam temp.} - \textit{outlet temp.}}\right)}$$

Inserting the respective temperatures in the present example, an average difference of 9.41 deg. F. is obtained, which gives an average transmission of 598 B.t.u. per square foot per hour per degree F.

The proportion of the condenser surface that is actually in contact with steam can be estimated approximately if we know the rates of transmission from pure steam to water and from air to water respectively. The transmission from saturated air is very low—that is, between 1 and 10 B.t.u. per square foot per hour per degree difference—and can, therefore, be neglected in comparison with the much greater transmission from steam. The transmission from pure steam to water flowing through brass tubes has been studied by numerous investigators and has been found to increase with both the velocity and the temperature of the water. Orrok made tests with a condenser consisting of a single 1-in. No. 18 B. & W. gage brass tube immersed in a current of pure steam. He used water velocities varying from 2.01 ft. per sec. to 8.91 ft. per sec., and by plotting his results it is possible to obtain with a fair degree of accuracy the transmission at any water temperature and at any velocity. It will first be necessary, however, to determine the water velocity.

In the test just given, 282,000,000 B.t.u. were absorbed per hour by a body of water which rose 8 deg. in temperature, indicating that 35,250,000 lb. of water per hour was used. The condenser is divided into two water passes, each of an approximate aggregate area of flow of 22.4 sq.ft. Assuming the density of the water to be 62.4 lb. per cu.ft., this gives a velocity of 7 ft. per sec. According to Orrok's results from the single-tube condenser, 7 ft. per sec., with a mean water temperature of 54 deg. F., should give a transmission of about 870 B.t.u. per square foot per hour per degree mean difference in temperature.

The logarithmic formula for mean temperature difference is independent of the amount of surface, being

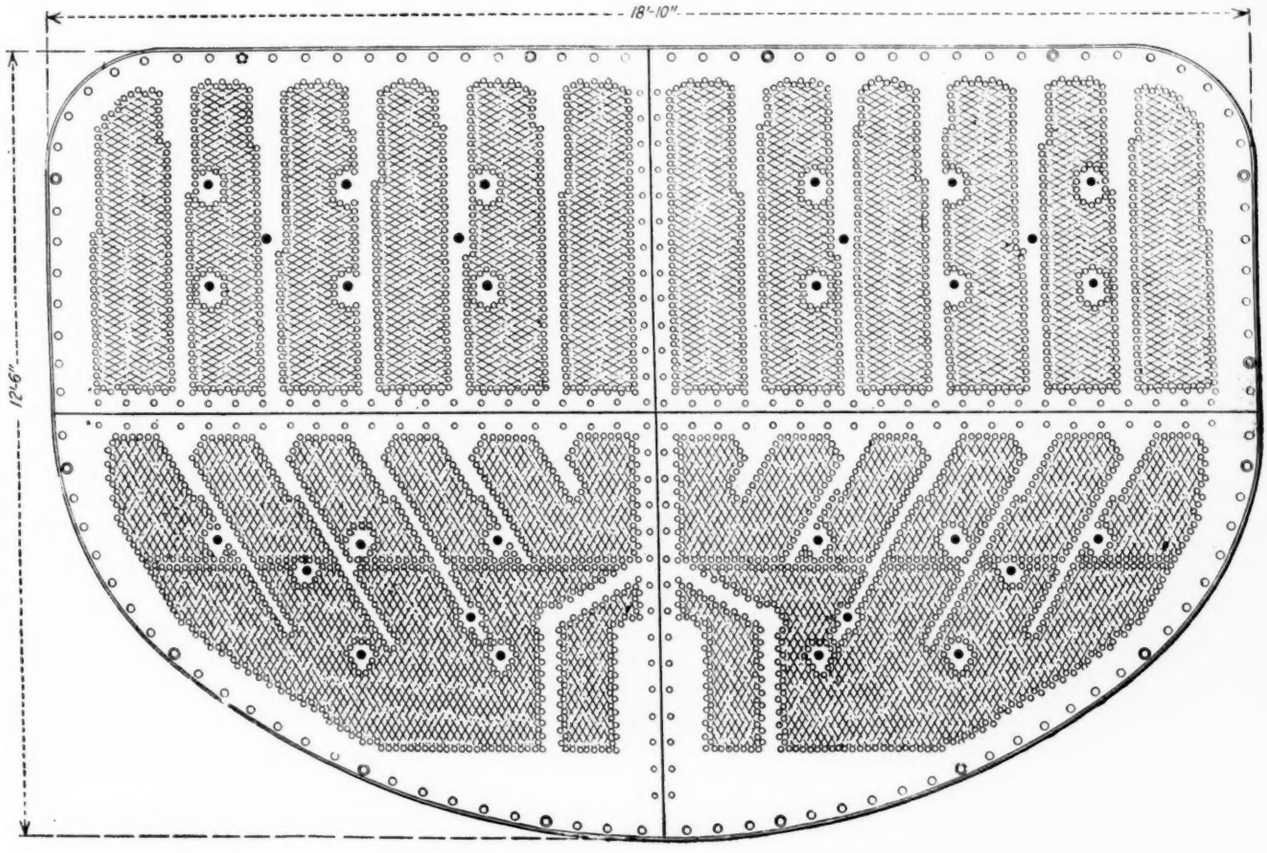



FIG. 1. LAYOUT OF TUBE PLATE OF WHEELER 50,000-SQ.FT. SURFACE CONDENSER

conditioned solely by the temperature of the steam and the temperature of the water at inlet and outlet, and we can, therefore, use the determined value of 9.41 deg. Dividing 282,000,000 B.t.u. per hour by 9.41 times 870 gives 34,200 sq.ft. as the portion of the condenser that was probably in active contact with steam. This is to be compared with the total heat-absorbing surface in the present condenser of 50,000 sq.ft., and considering the fact that a certain amount of surface must necessarily be reserved for cooling the air going to the air pump, and also the fact that the present condenser will at times be called upon to use much warmer circulating water, when the steam of lower specific volume will penetrate into the tube bank, indicates a remarkably efficient design. Under extreme hot-weather conditions

or when the condenser is more heavily loaded, still higher values of the average coefficient of heat transmission are to be expected.

The ability of this condenser to utilize so large a part of its surface in condensing steam at the maximum rate is in part due to the efficiency of the hurling-water type of air pump installed with it. This pump is able to care for a mixture containing a large amount of water vapor, the cold water at once condensing the vapor, which, in a dry vacuum pump, would have to be compressed. Measurements of the air leakage into the condenser were made on several different occasions during the period of the observations by connecting the air-pump suction to a rotative dry-vacuum pump delivering into an air bell. By this means the air leakage was found to vary between 8 and 11 cu.ft. of free air per minute. Referring to the curve in Fig. 2, it will be seen that the turbo air pump is able to handle this amount of air at a partial pressure of only 0.2 in. mercury column. At 9 o'clock on Dec. 2, the absolute pressure of the air-pump suction was 0.54 in. mercury. Subtracting 0.2 in. for air pressure leaves 0.34 for the partial pressure of the water vapor, giving a vapor temperature of 48.06 deg. F., which is surprisingly close to the inlet temperature of the circulating water.

The excellent cooling of the mixture going to the air pump thus obtained is the more remarkable in view of

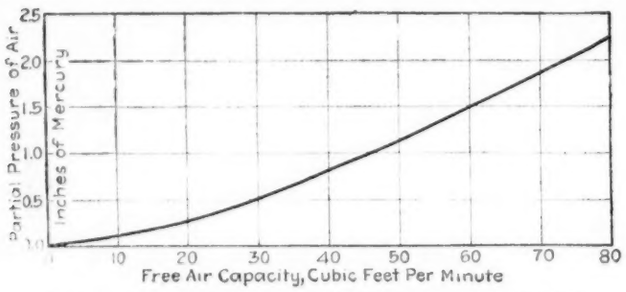



FIG. 2. VACUUM CAPACITY CURVE OF WHEELER TURBINE-DRIVEN TURBO AIR PUMP.

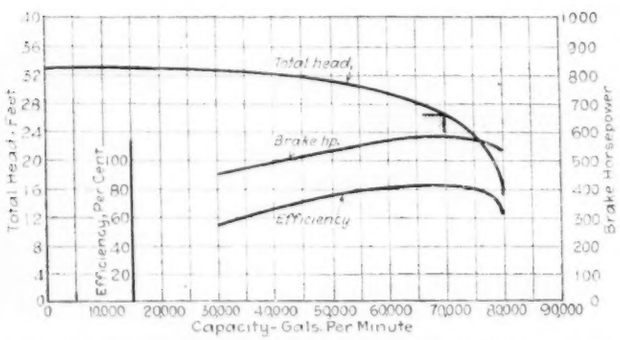



FIG. 3. CHARACTERISTICS OF WHEELER 18-IN. 280 R.P.M. BI-ROTOR CENTRIFUGAL CIRCULATING PUMP FOR 50,000-SQ.FT. CONDENSER

a condensate or hotwell temperature of 62 deg. F. The latter, it will be noted, is higher than the temperature of the circulating water at the outlet and is quite close to the inlet steam temperature (Fig. 4). This result, as also the small drop in pressure between turbine exhaust and air-pump suction—namely, 0.06 in. mercury—is secured by the steam lanes and wider spacing of tubes at the top of the condenser, both converging toward the air-pump suction and permitting free flow of steam deep into the condenser. Uncondensed steam is thus kept in contact with the condensate until it has reached nearly the bottom of the bowl-shaped shell, so that it is not chilled materially in traversing cold tubes. This result is highly valuable, as each 10 deg. F. in hotwell temperature is equivalent to about

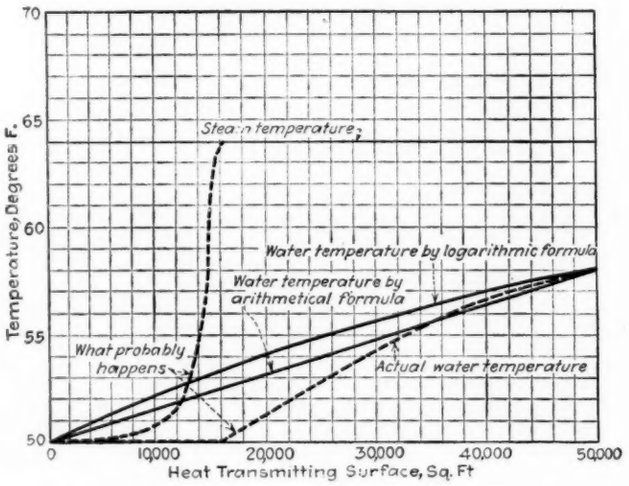



FIG. 4. THEORETICAL AND PROBABLE ACTUAL WATER TEMPERATURE CONDITIONS

1 deg. at the coal pile. The tubes over which the air mixture last passes in reaching the air-pump suction are sheltered from the warm condensate falling from above and are thus reserved solely for cooling the air mixture.

## Electricity Produced in 1920

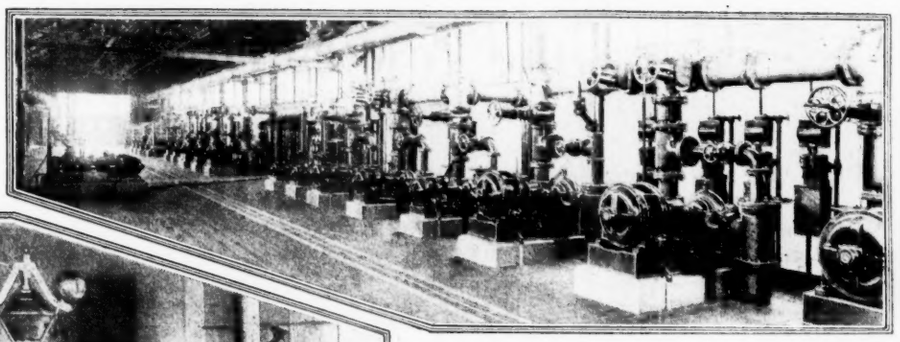
Figures are now available on the production of electricity in about 3,000 public-utility power plants of 100 kw. capacity or more which have made reports of their operation for 1920. The reports were collected and tabulated by the Geological Survey.

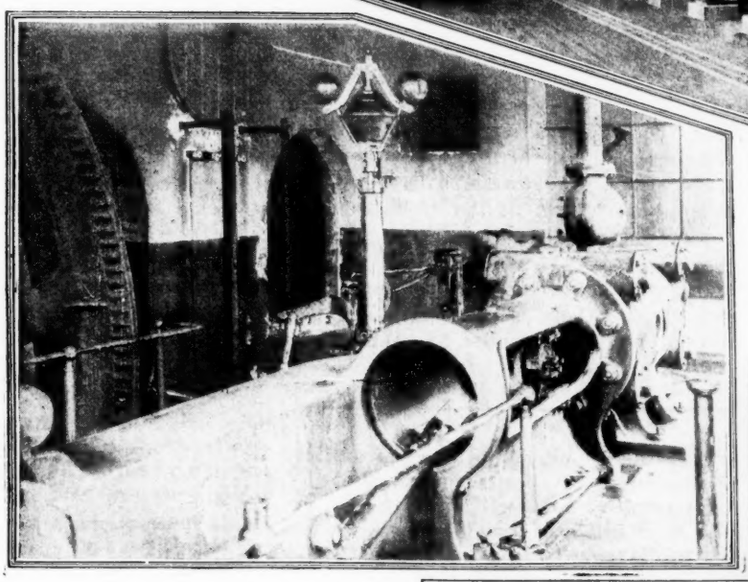
The mean daily output of electricity for each month of the year ranged from 115,600,000 kw.-hr. for May to 124,700,000 for January, and for the year, 120,000,000. The proportion of this output resulting from water power varied from 33 per cent in January to 42 per cent in May. The year's total production was 43,900,000,000 kw.-hr., of which 37½ per cent was from water power; this ratio was practically the same in 1919.

The year's production of 43,900,000,000 kw.-hr. was 12.9 per cent greater than that of 1919. The amounts of coal, fuel oil and gas used to produce this electricity, however, increased 6.0, 18.4 and 13.6 per cent respectively. The disproportionate increase in the consumption of fuel oil has a significant bearing on the question of our diminishing oil supply.

If the fuel oil, gas and wood consumed in generating electricity be converted to equivalent coal, the coal consumption in 1919 would be 38,500,000 tons and in 1920 it would be 41,200,000 tons—an increase of 7 per cent. The increase in the production of electricity for the same period was 12.9 per cent, which indicates a gain of efficiency in the consumption of fuels during 1920. On the basis of equivalent coal consumed for each of the two years, a kilowatt-hour of electricity was produced in public-utility plants in 1919 by 3.17 lb. of coal and in 1920 by 3.01 lb. These figures show a gain in economy of fuel consumption of 5 per cent, or a saving of about 2,000,000 tons of coal in the production of electricity in 1920 as compared with the rate of fuel consumption per kilowatt-hour in 1919.

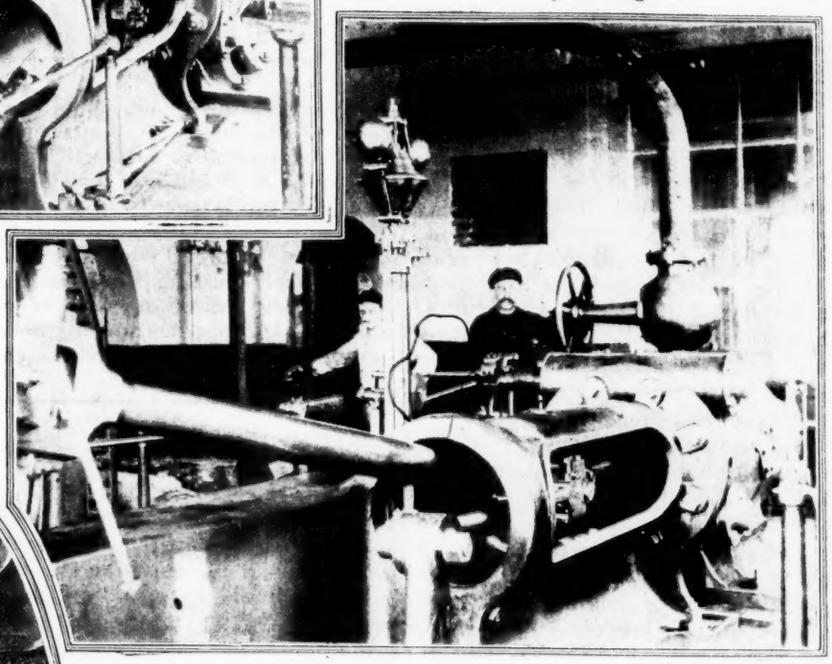
A line of single-stage DeLaval pumps ranging from 100 to 1,500 gal per min. capacity and from 65 to 115 ft. head in the Ford Motor plant at Detroit. Note the use of many small individual-drive pumps instead of a few large ones.



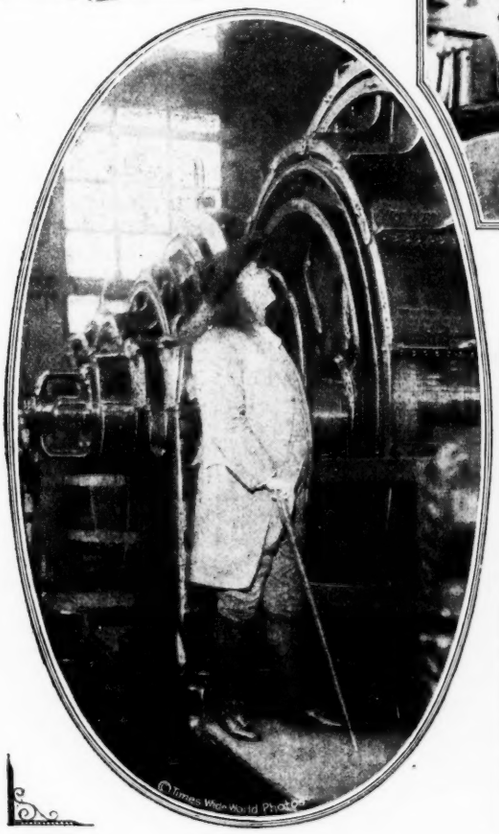


Left, engine room of the Noiret Textile Works at Fourmes, France, stripped by the Germans of every particle of brass, which they needed for making munitions.

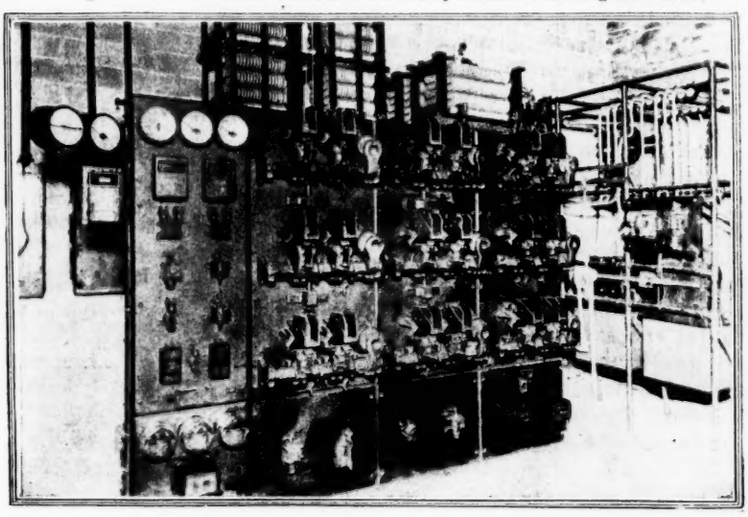
Below, the same room as it appeared in April, 1920, after repairs had been made and the plant put in operation again.



Ben Franklin once wished he might visit New York 100 years after his death. Here he is, impersonated by his great-great-great-grandson, Franklin Bache Huntington, inspecting the Pennsylvania R.R. station power house in a tour of New York recently made during "Thrift Week."




Switching equipment and control panels for a Westinghouse automatic substation recently installed in the new Hamm Building, St. Paul, Minn. A 500-kw. motor-generator set is cut in and out of service by a contact-making voltmeter.



# Maintenance-Department Methods—I. Keeping the Power-Plant Records

By HUBERT E. COLLINS

OF ALL maintenance-department records the most important are those pertaining to the power plant; all calculations of cost of power and very often matters of policy in the works are settled by findings based upon them.

The longer records are kept, the more valuable they become because of the time element in averages. Those of a few days or weeks do not so closely approximate the truth as those of a year; then the first year's averages form a basis of comparison with the second year's operation for reference and guidance.

Power-plant records are invaluable to the operating engineer in the operation of his plant. Knowing the average standards, a glance over the previous day's record will show whether he is doing as well as he should or not; if not, he can correct the mistakes before they are too old. The daily power-plant report enables him to do this. The owner is primarily interested in costs, both average and bulk, and these are obtainable from the monthly analysis of the daily reports, a summary of the month's operation. An owner does not want test results so much as a showing of every-day costs that he is called on to meet, whether for a department or the entire plant, and a year's average will show what may be expected in the way of attainment, and set the mark for betterment, if possible.

**The man in responsible charge of the power plant comes into intimate contact with the maintenance department and will find these three articles by Mr. Collins of special interest. The others will be "Organization and Scope" and "Distributing the Costs." When you have read them, send "Power" your ideas and suggestions; a chart showing how your maintenance department functions with respect to the generation and application of power; inspection and precautionary methods, etc.**

The commercial cost of a boiler horsepower or kilowatt-hour is what is sought by an owner, by including every item of expense that enters into consideration, with the actual every-day average performance in production. To this end the basis of all calculations is the actual evaporation of water per pound of fuel in the boiler room, and we must pay the most careful attention to the weighing of fuel and measurement of feed water.

With this must be kept an accurate record of the cost of each day's fuel following the varying market prices. The owner pays for fuel as delivered in the boiler room; if it is bad fuel, he pays for it just the same. In estimating commercial costs, we should therefore consider the actual evaporation, uncorrected, for the owner pays for the bad as well as the good.

With the foreging considerations in view, the accompanying three forms, two for daily power-plant reports and one for monthly analysis, are offered as actual examples in every-day use. These are the result of about eight years of effort in laying out such models for the use of the average manufacturing plant. Such forms are now in use and have been for some years in several power plants connected with factories.

Forms 1 and 2 for daily power-plant reports are shown for the reason that one the size of No. 1 will cover, as it does, a 7,500-hp. plant and No. 2 will cover 2,500-hp. and under. The monthly analysis form, No. 3 will cover a plant of almost any size.

In preparing these forms a standard unit size should be adopted, form No. 1 (11 x 17 in.), being a multiple of Nos. 2 and 3 (8½ x 11 in.), the latter being suitable for filing in a standard letter file.

Recording instruments should be used in securing all the data for this report except for the machine "Hours Run," at the right, which must come from the records of the operating engineer.

Coal weighing is a problem that in some cases calls for considerable apparatus, but is so important that there is no need of keeping any records at all if this is not attended to. With ram stokers counters can be used on each stoker and summarized each day. Ash can either be weighed on scales as it goes out or computed after the weight of the content of containers has been ascertained. Feed-water meters are next in importance and it is the writer's conviction that neither disc nor turbine meters are to be relied upon for feed-water measurement, as both the rate of flow and temperatures are too variable. Some well-known make of V-notch or U-tube measuring device is the best for this work and even with these the operator must not rely on the instruments' giving good service without constant attention; in fact this latter rule holds good for all kinds of recording instruments.

The calculations of results shown on the daily report (right-hand lower corner) are of vital importance, and in the majority of small plants the operating engineer must be the one to make them. As few operating engineers in small plants are familiar with these calculations, the following simple instructions are given.

### Rules for Calculations on Daily Power-Plant Reports

Evaporation per Pound of Fuel.—Literally, this is the pounds of feed water evaporated or pounds of steam generated for each pound of fuel.

Rule: Divide the pounds of feed water for a given period by the pounds of fuel consumed for the same period.

Percentage of Ash.—Rule: Divide the amount of ash in pounds by the amount of fuel in pounds for a given period.

Rate of Combustion.—This means the amount of fuel burned per square foot of grate area in service per hour.

Rule: First divide the pounds of fuel consumed in pounds by the number of hours run; second, divide the result by the number of square feet of grate area in service.

Total Pounds of Steam Produced.—The total amount of feed water for a given time as shown by the meter.

Rating of Boilers in Service.—Taken from the table of boiler data on the report sheet, and the hours run of given boilers.

# DAILY POWER PLANT REPORT

OUTSIDE TEMPERATURE _____ °F

DATE _____ 192

| TIME | STEAM PRESSURES: BOILER ROOM | STEAM PRESSURES: ENGINE ROOM | STEAM PRESSURES: HOT WATER HEATERS 1 | STEAM PRESSURES: HOT WATER HEATERS 2 | WATER PRESSURES: HOT WATER FLOW MAINS 1 | 2 | 3 | 4 | WATER PRESSURES: HOT WATER RETURNS | CITY WATER | TO BAROMETRIC CONDENSERS | DRAFT PRESSURES: GROUP "A" BOILERS: UNDER GRATE | OVER GRATE | BACK PASS | STACK | GROUP "B" BOILERS: UNDER GRATE | OVER GRATE | BACK PASS | STACK | VACUUM: BAROMETRIC CONDENSERS 1 | 2 | AIR PUMPS 1 | 2 | TEMPERATURES: FEED WATER | HEATING: FLOW | RETURN | BASE OF STACKS: BRICK | STEEL STACKS 1 | 2 | 3 | 4 | 5 | COOLING POND | CONDENSER DISCHARGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6AM | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12M | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 PM | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12MT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 AM | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AV | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

## TOTAL AMOUNT STOKER RAM COUNTER READINGS

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FINISH | | | | | | | | | | | | | | | | | | |
| START | | | | | | | | | | | | | | | | | | |
| DIFFERENCE | | | | | | | | | | | | | | | | | | |

## METER READINGS

| | FEED WATER | No. | No. | No. | No. | No. | No. | No. | No | No |
|---|---|---|---|---|---|---|---|---|---|---|
| FINISH | | | | | | | | | | |
| START | | | | | | | | | | |
| DIFFERENCE | | | | | | | | | | |

## STEAM FLOW

| | AIR | STEAM | STEAM | STEAM | STEAM | STEAM | STEAM | STEAM | STEAM | STEAM | STEAM | STEAM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FINISH | | | | | | | | | | | | |
| START | | | | | | | | | | | | |
| DIFFERENCE | | | | | | | | | | | | |

## KILO WATT HOUR

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| FINISH | | | | | | | |
| START | | | | | | | |
| DIFFERENCE | | | | | | | |

## COAL RECORDS

| POUNDS | BITUMINOUS | ANTHRACITE |
|---|---|---|
| ON HAND | | |
| RECEIVED | | |
| TOTAL ON HAND | | |
| USED | | |
| ON HAND | | |

## FUEL OIL RECORD

| | | | | |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

## BOILER DATA

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NO. AND SIZE TUBES | | | | | | | | | | | | | | | | | | | |
| HEATING SURFACE | 5000 sq. ft. | 5000 sq. ft. | 2500 sq. ft. | 2500 sq. ft. | 2500 sq. ft. | 2500 sq. ft. | 2500 sq. ft. | 2800 sq. ft. | 5000 sq. ft. | 5000 sq. ft. | 5000 sq. ft. | 5000 sq. ft. | 5000 sq. ft. | 5000 sq. ft. | 5000 sq. ft. | 5000 sq. ft. | 5000 sq. ft. | 5000 sq. ft. | 75000 sq. ft. |
| H. P. RATING | 500 | 500 | 250 | 250 | 250 | 250 | 250 | 250 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 7800 |
| GRATE AREA | 89 sq. ft. | 89 sq. ft. | 44.6 sq. ft. | 44.6 sq. ft. | 44.6 sq. ft. | 44.6 sq. ft. | 44.6 sq. ft. | 44.6 sq. ft. | 89 sq. ft. | 89 sq. ft. | 89 sq. ft. | 89 sq. ft. | 89 sq. ft. | 89 sq. ft. | 89 sq. ft. | 89 sq. ft. | 89 sq. ft. | 89 sq. ft. | 1335.6 sq. ft. |
| RATIO H. S TO G. A. | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 | 56.1 |

## NOTES

HOURS RUN — TIME: 6A 7 8 9 10 11 12M 1 2 3 4 5 6 7 8 9 10 11 12 1A 2 3 4 5 TOTAL — TOTAL

- BOILERS: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
- GENERATORS: TURBO 1 2 3 4 5; Recip-rocat 6 7
- PUMPS: Feed 1 2; Heat 1 2; Cool Lb. 1 2; Vac-uum 1 2
- CONDENSERS: Barro-metric 1 2; Jet 3 4
- DRAFT FANS: FORCED 1 2 3 4 5; INDUCED 6 7 8 9 10
- Coal Convey

## CALCULATIONS

| | |
|---|---|
| TOTAL AMOUNT FUEL USED | |
| TOTAL AMOUNT ASH PER DAY | |
| PERCENTAGE ASH | |
| RATE OF COMBUSTION | |
| TOTAL POUNDS OF STEAM PRODUCED | |
| RATING OF BOILERS IN SERVICE | |
| B. H. P. PER HOUR DEVELOPED | |
| PERCENTAGE OF RATING PRODUCED | |
| EVAPORATION PER SQ. FT. H. S. | |
| AVERAGE BOILER PRESSURE | |
| AVERAGE TEMPERATURE OF FEED WATER | |
| FACTOR OF EVAPORATION | |
| EVAPORATION PER POUND OF FUEL | |
| EVAPORATION PER POUND OF COMBUSTIBLE | |
| EQUIVALENT EVAP. PER POUND OF FUEL | |
| EQUIVALENT EVAP. PER POUND OF COMBUSTIBLE | |
| COST OF FUEL PER POUND | |
| POUNDS OF FUEL PER B. H. P. | |
| COST OF FUEL PER B. H. P. | |

SIGNED _____ PLANT ENGINEER

FORM 1. FOR USE IN LARGER PLANT; ACTUAL SIZE SHOULD BE 11 x 17 IN.

Boiler Horsepower per Hour Developed.—Rule: First, divide the pounds of feed water for a given period by 30; second, divide the result by the number of hours run.

Percentage of Rating Produced.—Rule: Divide the boiler horsepower per hour developed by the rating of boilers in service.

Evaporation per Square Foot of Heating Surface.—This is the amount of steam evaporated per square foot of heating surface in service per hour.

Rule: First divide the total amount of feed water for a given period by the number of hours run; second, divide the result by the total number of square feet of heating surface in service for the given period.

Equivalent Evaporation per Pound of Fuel.—Multiply the evaporation per pound of fuel by the factor of evaporation.

Equivalent Evaporation per Pound of Combustible.—Multiply the evaporation per pound of combustible by the factor of evaporation.

Cost of Fuel per Pound.—Cost of fuel per ton on boiler-room floor divided by the pounds per ton.

Pounds of Fuel per Boiler Horsepower.—Rule: Divide 30 by evaporation per pound of fuel.

Cost of Fuel per Boiler Horsepower.—Rule: Multiply the cost per pound of fuel by the pounds of fuel per boiler horsepower.

## DAILY POWER PLANT REPORT

OUTSIDE TEMP ..... °F ..... 192...

| TIME | PRESSURES: STEAM: BOILER ROOM | ENGINE THROTTLE 1 | 2 | 3 | RECEIVERS 1 | 2 | 3 | HEAT SYSTEM | FLUE GAS: UNDER GRATE | OVER GRATE | STACK 1 | STACK 2 | WATER MAIN | TEMPERATURE: FEED WATER | FLUE GAS: STACK 1 | STACK 2 | VOLTAGE | HOURS RUN: ENGINES 1 | 2 | 3 | BOILERS 1 | 2 | 3 | 4 | 5 | AIR COMP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.00 A. M | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 M | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.00 P. M | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 A. M | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5.00 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| AVER | | | | | | | | | | | | | | | | | | | | | | | | | | |

COAL RECORD: ON HAND; REC'D; TOTAL; USED; ON HAND

POWER METER: PRESENT; PREVIOUS; DIFF

LIGHT METER: PRESENT; PREVIOUS; DIFF

FEED WATER METER: PRESENT; PREVIOUS; DIFF

WATER METER: PRESENT; PREVIOUS; DIFF

GAS METER: PRESENT; PREVIOUS; DIFF

ASH REMOVAL: POUNDS

CALCULATIONS

| | | | |
|---|---|---|---|
| TOTAL FUEL USED | | AVERAGE TEMP OF FEED | |
| ASH | | FACTOR OF EVAPORATION | |
| PERCENTAGE ASH | | EVAP PER LB FUEL | |
| RATE OF COMBUSTION | | " " COMBUSTIBLE | |
| TOTAL POUNDS STEAM USED | | EQUIV EVAP PER LB FUEL | |
| RATING OF BOILERS IN SERVICE | | " " " COMBUSTIBLE | |
| B H P PER HOUR DEVELOPED | | COST OF FUEL PER LB | |
| PER CENT OF RATING PRODUCED | | POUNDS PER B H P | |
| EVAPORATION PER SQ FT H S | | COST " " " | |
| AVERAGE BOILER PRESSURE | | | |

BOILER DATA

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| SQ FT H S | 850 | 1300 | 1300 | 2500 | 2500 |
| RATING | 85 | 130 | 130 | 250 | 250 |
| SQ FT G A | 24 | 27 | 27 | 60 | 60 |
| RATIO H.S TO G.A | 35:1 | 48:1 | 48:1 | 42:1 | 42:1 |

SIGNED ..... ENGINEER

FORM 2. FOR USE IN SMALLER PLANT: ACTUAL SIZE 8½ x 11 IN.

Average Boiler Pressure.—Taken from the boiler-pressure column of report.

Average Temperature of Feed Water.—Taken from corresponding column of the report.

Factor of Evaporation.—Using a steam table such as found in Kent's or some other hand book.

Rule: (1) Get heat units in pounds of steam at average boiler pressure. (2) Get heat units in a pound of feed water at the average feed water temperature. (3) Subtract the second sum from the first. (4) Divide the remainder by 970.4.

Evaporation per Pound of Fuel.—Rule: Divide the total amount of feed water for a given period by the total amount of fuel for the same time. Both amounts in pounds.

Evaporation per Pound of Combustible.—Rule: First, subtract the total weight of ash from the total weight of fuel; second, divide the total amount of feed water for a given period by the above remainder.

Other data necessary to a complete yearly record are the number of heating hours per year. If the heating is by steam, there must be a column on the daily report sheet for recording the steam pressure on the heating system. The heating hours can be taken from this column. Form 2 is laid out for a hot-water heating system, and the heating hour record can be taken from the heat-temperature columns.

The data on the monthly analysis must be secured by co-operation of the power-plant engineers and the accounting department. Items of boiler-room expenses to be secured from the accounting department are on Form 3, Nos. 15, 18, 19, 20, 21, 22, 25, 26, 27, 28, 29 and 30. Items of engine-room expense to be secured from the accounting department are on Form 3, Nos. 11, 14, 15, 16, 17, 18, 19, 20, 21 and 22. All other items can be

estimated by the plant or maintenance engineer from his own records.

The daily power-plant reports should be accompanied by charts giving in graphic form the results covered by the calculations, as most executives to whom these reports are of interest prefer to have the reports given them in chart form.

Next to the maintenance engineer the monthly analysis is of most value to the general manager, and a copy should go to each every month.

MONTHLY ANALYSIS POWER PLANT REPORTS MONTH OF _____ 192__

| BOILER ROOM | | TOTAL | AVERAGE |
|---|---|---|---|
| 1 | POUNDS STEAM PRODUCED | | |
| 2 | BOILER HORSE POWER PRODUCED | | |
| 3 | BITUMINOUS COAL CONSUMPTION | | |
| 4 | ANTHRACITE COAL CONSUMPTION | | |
| 5 | AVERAGE FEED WATER TEMPERATURE | | |
| 6 | AVERAGE FLUE GAS TEMPERATURE (BASE OF STACK) | | |
| 7 | AVERAGE BOILER PRESSURE | | |
| 8 | AVERAGE FLUE GAS PRESSURE | | |
| 9 | AVERAGE FACTOR OF EVAPORATION | | |
| 10 | AVERAGE EVAPORATION PER POUND OF FUEL | | |
| 11 | AVERAGE EVAPORATION PER POUND OF COMBUSTIBLE | | |
| 12 | AVERAGE EQUIVALENT PER POUND OF FUEL | | |
| 13 | AVERAGE EQUIVALENT PER POUND OF COMBUSTIBLE | | |
| 14 | AVERAGE PERCENTAGE OF ASH | | |
| | CURRENT EXPENSES | | |
| 15 | COST OF FUEL DELIVERED TO STORAGE | | |
| 16 | COST OF FUEL DELIV'ED FROM STORAGE TO BOILER ROOM (COAL HANDL'G, LABOR & MOTOR) | | |
| 17 | TOTAL COST OF FUEL TO BOILER ROOM | | |
| 18 | WAGES OF FIREMEN AND WATER TENDERS | | |
| 19 | WAGES OF BOILER REPAIR MEN | | |
| 20 | WAGES OF LABOR AND FIREROOM ENGINEER (LEAVING OUT COAL HANDLING) | | |
| 21 | GENERAL SUPPLIES | | |
| 22 | REPAIRS (ASIDE FROM BOILER REPAIR WAGES) | | |
| 23 | LIGHT | | |
| 24 | POWER (ALL MOTORS IN BOILER ROOM) | | |
| 25 | GENERAL EXPENSES | | |
| 26 | DEPRECIATION (BALANCE OF 10% ON EQUIPMENT ADDED TO ITEM 22) | | |
| 27 | INSURANCE (FIRE) | | |
| 28 | INSURANCE (BOILER) | | |
| 29 | INSURANCE (EXPLOSION) | | |
| 30 | TAXES | | |
| 31 | STEAM FOR FEED PUMP | | |
| 32 | TOTAL COST OF STEAM PRODUCTION | | |
| 33 | COST OF COAL PER POUND | | |
| 34 | POUNDS COAL PER B. H. P. | | |
| 35 | COST OF COAL PER B. H. P. | | |
| 36 | TOTAL COST PER B. H. P. | | |
| 37 | COST OF EVAPORATION PER 1000 LBS. STEAM | | |

NOTES

FEED PUMP OPERATION SUPPLIES AND REPAIRS TO BE INCLUDED IN ITEMS 20 22 27 30
FEED PUMP STEAM TO BE CHARGED AT COST PER 1000 LBS
MAINTENANCE, OPERATION, AND TAXES OF HEATING SYSTEM TO BE DEDUCTED AND CHARGED TO HEATING

| ENGINE ROOM | | TOTAL | AVERAGE |
|---|---|---|---|
| 1 | TOTAL KILO WATT HOURS PRODUCED | | |
| 2 | KILO WATT HOURS PRODUCED FOR LIGHT | | |
| 3 | KILO WATT HOURS PRODUCED FOR POWER | | |
| 4 | TOTAL STEAM USED FOR GENERATORS AND AUXILIARIES | | |
| 5 | KILO WATT HOURS PURCHASED FOR LIGHT | | |
| 6 | KILO WATT HOURS PURCHASED FOR POWER | | |
| 7 | TOTAL KILO WATT HOURS PURCHASED | | |
| 8 | AVERAGE VOLTAGE | | |
| 9 | AVERAGE WATER RATE PER KILO WATT HOUR | | |
| 10 | AVERAGE POUNDS COAL PER KILO WATT HOUR | | |
| | CURRENT EXPENSES | | |
| 11 | WAGES, ENGINEERS, ATTENDANTS, LABOR (INCLUDING COOLING POND) | | |
| 12 | COST OF STEAM FOR GENERATORS AND AUXILIARIES | | |
| 13 | COST OF POWER FOR PUMPS AT COOLING POND | | |
| 14 | GENERAL SUPPLIES | | |
| 15 | REPAIRS | | |
| 16 | LIGHT | | |
| 17 | POWER | | |
| 18 | GENERAL EXPENSES | | |
| 19 | DEPRECIATION | | |
| 20 | INSURANCE (FIRE) | | |
| 21 | INSURANCE (EXPLOSION) | | |
| 22 | TAXES | | |
| 23 | TOTAL COST OF KILO WATT HOUR PRODUCTION | | |
| 24 | TOTAL COST PER KILO WATT HOUR | | |
| 25 | COST OF PURCHASED LIGHT | | |
| 26 | COST OF PURCHASED POWER | | |
| 27 | TOTAL OF PURCHASED CURRENT | | |

NOTES

ITEM 12 ESTIMATED AT RATE OF ITEM 37 IN BOILER ROOM

SIGNED _____
PLANT ENGINEER

FORM. 3. SHOWING MONTHLY ANALYSIS: ACTUAL SIZE 8½ x 11 IN.

## A Case of Faulty Piping

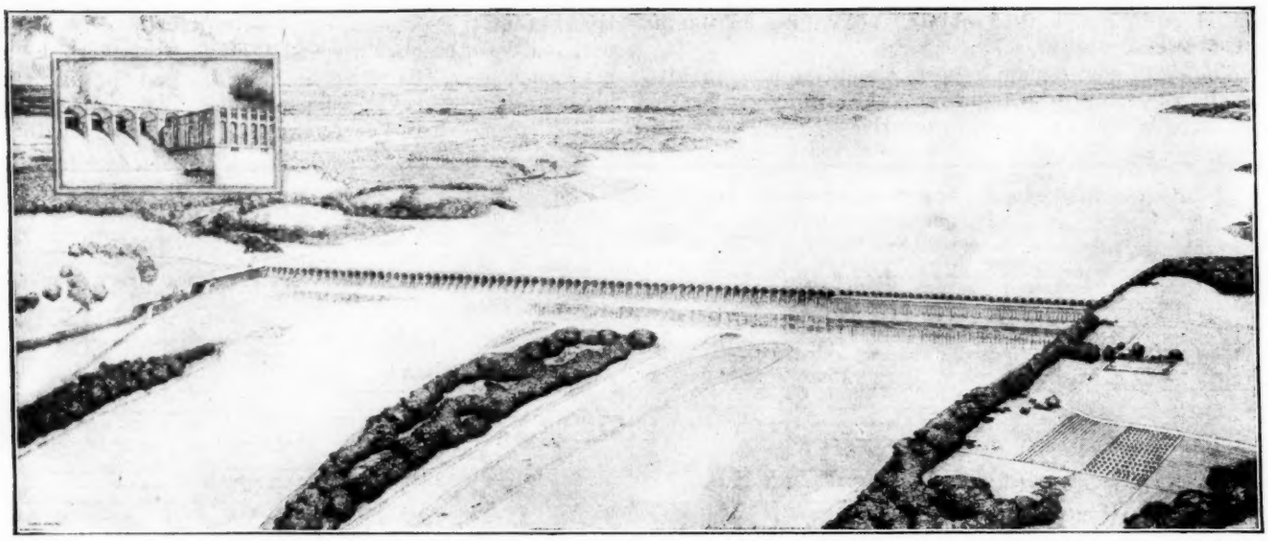
BY A. C. McHUGH

A new engineer at a certain institution, upon looking over the plant to see if any improvements could be made, noticed among other things that the steam connections to the eight large steam kettles in the kitchen were leaking badly. He set about stopping them, and while at work on one of the worst leaks the chef came in and said that as soon as the leaks were stopped the kettle would refuse to cook and that he had asked the previous engineer to let the leaks alone.

Knowing that something must be wrong with the system, the engineer started an investigation. The kettles were connected to a live-steam header and to a return header. The connections to the return or drip header were all fitted with check valves and it was found that one of these checks had been put in in a reversed position, but the chef assured him that this kettle was his best cooker. The two headers dropped through the kitchen floor and ran about twenty-five feet to the heater room, where the return line was connected to a receiver, which was trapped to the main return to the boiler room. This trap was found to be in good condition.

The engineer decided to trace all the lines, and after crawling under the kitchen found that the steam-fitter, after connecting up the live steam header, had simply dropped his main steam line about one foot, using a right and left coupling, put in a tee and ran his drip connection into it, and then ran back to the receiver. This formed a steam loop, which, considering the length of the run, gave little opportunity for drainage. Naturally, the leaks had assisted in draining the kettles, as the chef had stated.

After the engineer had disconnected the two lines and fixed the leaks the kettles gave much better service, but believing there was still room for improvement he obtained eight small thermostatic traps, placed one in the drip connection of each kettle and connected the drip line from these directly into the main boiler-room return line. This proved so satisfactory that it was possible to cut the length of steam service to the kitchen by one hour a day, which meant some saving in fuel, not to mention the convenience to the kitchen force.



# Hydro-Electric Project at Muscle Shoals

## Five-Hundred-Thousand-Horsepower Project at Wilson Dam, to Supply Power at 4 Mills per Kilowatt-Hour for Continuous, and 1.2 Mills for Surplus Energy

By A. S. McBRIDE

WITH a million cubic yards of concrete to be poured and a schedule calling for nearly 40,000 yards of this to be placed each month the Engineer Corps of the Army had a splendid argument for the appropriation of $10,000,000 which was requested in the last Congress, for the work of the fiscal year beginning July 1. However, this appropriation was not granted and this project, one of the largest ever undertaken by the Federal Government, will therefore have to stand only 30 per cent complete until further appropriations are available. If the appropriations had been made as requested, it was expected that generation of energy could have started within three years. However, unless an item for this work is added to the Army bill which remains over for the new Congress, the work may be indefinitely delayed.

This project is really a wartime measure, for it was first authorized by the President when he set aside $13,000,000 from the national defense funds on Feb. 23, 1918, and authorized undertaking construction of the dam and power house. Subsequently, $4,000,000 additional was made available from these national defense funds, and it is believed that this amount will be entirely expended by June of the present year.

### The Cost and Scope of the Project

The entire project thus far authorized is now estimated to cost between forty-five and fifty million dollars. The original estimates of seventeen to twenty million dollars were based upon pre-war cost of labor and materials. As stated by General Taylor in commenting upon this situation, the original cost contemplated good labor at $1.50 per day, whereas now a minimum of $3.60 per day is paid for relatively poor labor. Corresponding increases in costs of cement and other materials which contribute largely to the total have also occurred, so that the present total estimate represents simply the original sum transformed into present cost units.

The proposed dam and power house is a structure 4,200 ft. long located on the Tennessee River 2.7 miles above France, Alabama. At this point there are now two channels separated by Jackson Island and in one of the channels the lock of the Muscle Shoals Canal. As a part of the new installation there will be locks providing for navigation past the dam with a total lift amounting to 90 ft. above the level of the proposed lower pool.

The completion of the dam will also facilitate navigation above this point, for it is estimated that the storage will extend in sufficient depth for 17 miles above the dam to provide for navigation by the typical canal barges requiring approximately six feet of depth. The level above the dam will be closely controlled, only a very few feet of variation throughout the entire year being expected because of the ample provision of spillway gates along two-thirds of the length of the structure. The fixed dam is surmounted with movable crest gates fifteen feet high. It is estimated that these gate structures are ample to care even for the extreme flood stage, which is variously estimated from 500,000 to 700,000 second-feet flow, without excessive variation in forebay water level.

### Present Status of the Project

As indicated in the foregoing, there still remain to be poured approximately 1,000,000 cu.yd. of concrete work, and progress has been made at the rate of nearly 40,000 cu.yd. a month. At this rate only twenty-five months would be required for completion. Of the $17,000,000 thus far made available and other very limited sums which arise from miscellaneous allotment to the work, there remained only about $9,500,000 available at the end of the last fiscal year, July 1, 1920. This sum has been expended at the rate of nearly $1,000,000 a month thus far.

The estimates made a year ago were that not more than $10,000,000 could be expended efficiently during

the next fiscal year, and this sum was therefore requested of Congress. The House of Representatives considered this request in the sundry civil appropriation bill, but after debate on the floor of the House the item was dropped out. The Senate Committee on Appropriations gave favorable consideration to the item, recommending it to the Senate by which body it was adopted. But the House of Representatives refused to agree, after a vigorous effort on the part of the opposition; and at the close of the session, the Senate finally abandoned the appropriation for the present Congress. It may therefore be necessary to stop the present work even before June, in order to conserve some funds for care of the project during the summer, or until such time as additional funds are appropriated. This is deemed by all interested persons to be a most unfortunate possibility, for the organization is now built up for rapid work and more than 4,400 men have been working during recent months. To allow this going organization to be disbanded and to require that the work be held in abeyance for a year would seriously increase the cost of the undertaking. It has been estimated variously that the losses from suspension of the work one single year would certainly be between four million and ten million dollars. The loss in interest upon the investments already made in the project and in the nitrate plant which is intimately associated with the entire development alone would amount to millions. One estimate made by the economists shows that the loss due to one year's suspension would be greater than the required appropriation, but it is not evident as yet whether even this argument will be sufficient to provide incentive for continuance of the work.

In connection with the estimates of cost for interruption of construction work, the figures that have been furnished to the Engineer Corps by the consulting engineer of the project are particularly pertinent. Mr. Cooper states his opinion upon this matter as follows:

> On the second question, as to the cost of closing down the work at this time, this is difficult to answer. It is not conceivable that the Government would withdraw from this project entirely, in view of the more than twelve millions of dollars already invested, and the showing in the foregoing paragraphs. In order to estimate the cost of a shutdown it would be necessary to have a basis as to the date when work would be resumed, so that the loss in interest might be computed. If the work should shut down at this time to be resumed, say, in three years, I am of the opinion that the combined losses to the Government would be around four million dollars and without any compensation therefor unless the Government might claim there was a compensation to be expected in waiting for a lower interest rate three years from now than can be obtained at this time. This amount of saving would be very small as compared to the four million dollars loss. The four million dollars would represent a loss of interest during three years on twelve million dollars, and on the construction side the loss of all of the cofferdams which are now in place, the loss of the construction bridge, the removal and re-erection of a large amount of construction derricks, tracks, concrete mixers and rock crushers and other construction equipment. The job would also have to suffer the losses incident to the breaking up of the construction organization which has been assembled at necessarily large expense, and I feel very certain that collectively the above losses would be a minimum of four million dollars and might easily amount to four and one-half million dollars.

The present status of the construction work may be seen in Fig. 1 and 2.

### Power-House Construction

The power house proposed is to consist of eighteen units. However, only four of these units are to be installed at once, and it is probable that only these will be needed within the first year or two of operation. It is realized that it will take several years to develop the market for the entire project, even assuming a very low selling price of 1.2 mills per kilowatt-hour for the secondary power and 4 mills per kilowatt-hour for the primary power at the low-tension busbars of the generating station. On this basis Hugh L. Cooper, consulting engineer for the project, estimates that it will take ten years to load the plant after it is completed and begins generation from the initial units. However, it is expected that the foundations for the entire power house will be installed initially so that addition of units will be made at a minimum of expense and delay.

The initial installation of I. P. Morris waterwheels provides units of 30,000 hp. each. These wheels will be connected to Westinghouse generators.

Work on the foundations has progressed so far during the past summer that orders were placed for the four waterwheels required, and delivery of these is

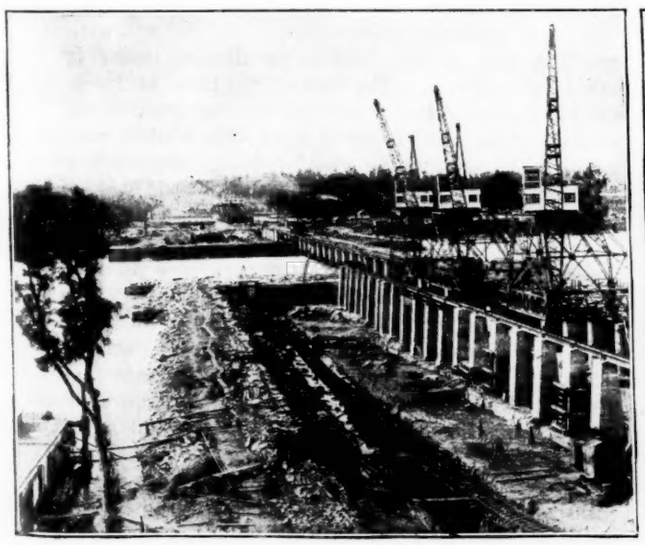


FIG. 1. VIEW OF THE WORK IN COFFERDAM NO. 1 FROM THE NORTH SHORE

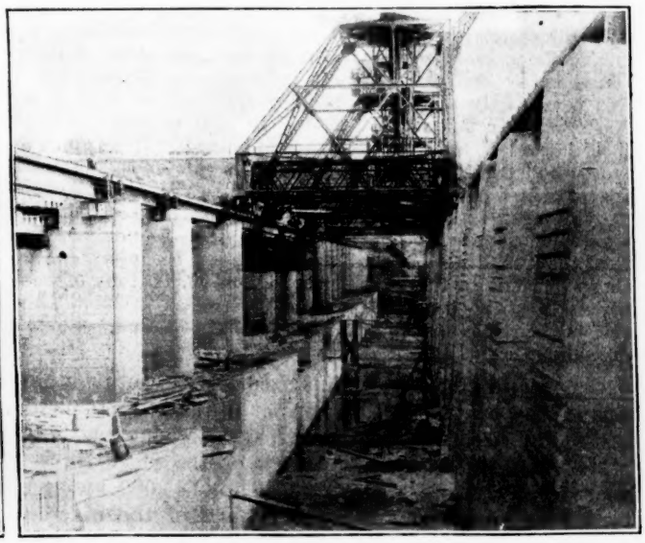


FIG. 2. VIEW INSIDE OF COFFERDAM NO. 1, SHOWING DAM MASONRY AND CONSTRUCTION PIERS

scheduled for Sept. 15, 1921. These units are estimated to cost the Government $129,500 each, or a total of $518,000.

According to the plans the waterwheels will operate under 92 ft. head. The general plan for the triple-channel intake in relation to the position of the generating unit is seen in Fig. 3, which also indicates the type of rectangular reinforcement used in inclosing the intake passages.

### Power Estimated to Be Available

In order to review the power estimates previously made, Hugh L. Cooper, consulting engineer for the project, has recently completed an exhaustive analysis of the proposed plans under the instructions of Brig-

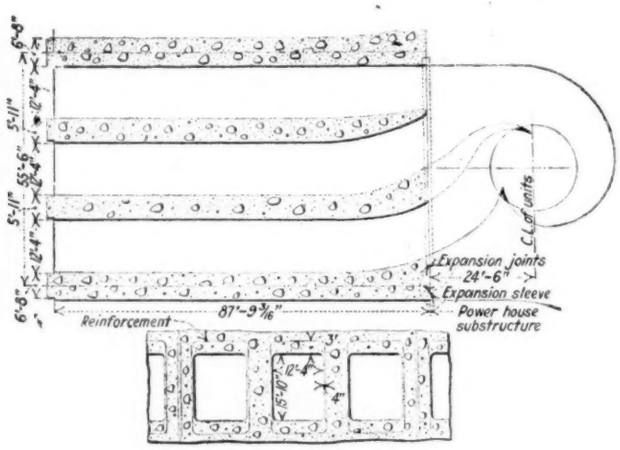



FIG. 3. TURBINE INTAKE, SHOWING TRIPLE-CHANNEL ARRANGEMENT

adier General Taylor, assistant chief of engineers. Mr. Cooper has reported upon the project with an estimate of 700,000,000 kw.-hr. per annum as the available primary production and 1,470,000,000 kw.-hr. per annum of secondary power production.

In connection with his estimates of power to be available from the project, Mr. Cooper has also estimated the coal equivalent and the advantage in conservation of fuel which can be expected from the project. In this connection he makes the following statement:

In the territory reachable from the Wilson Dam the present coal consumption in steam-operated industries will be found in excess of six pounds of coal per kilowatt-hour, and is probably more than eight pounds per kilowatt-hour. Assuming six pounds, the saving in coal by the complete installation of the works as now planned will amount to more than 6,500,000 tons per annum if this energy is used for standard normal domestic purposes. If the plant is used otherwise than above indicated (for fertilizer, for instance) such other use will not, of course, be adopted unless the resulting benefits are found to be in excess of those incident to the conservation of 6,500,000 tons of coal per annum, and therefore one should be safe in submitting the coal-saving quantities as a basis for Congressional determination of future action.

General Taylor has summarized the power possibilities of the project in a somewhat different way in his testimony before the committees of Congress. He states that the extreme low flow of the river for ten years shows not less than 85,000 hp. (64,000 kw.) recorded at any time. But in only six of the nineteen recorded years did the low river discharge fall below the equivalent of 100,000 hp. In fact, it was below this figure only 1.3 per cent of the total time. Furthermore it is believed that with the storage available at least 500,000 hp. additional can be generated for eight months of the year. This secondary horsepower, it is proposed by Secretary of War Baker, should be applied to industrial operations such as the nitrate plant owned by the Government at Muscle Shoals. The primary horsepower would thus be available for distribution throughout the district without interruption.

### Cost of Power Production

In connection with his estimate of power capacity Mr. Cooper has also been asked to comment upon power costs. He reports on several phases of this question in a communication of November 27 as follows:

In determining the amount of power that should be developed at the Wilson Dam we have carried out your instructions to figure that ten years of time will be required to load the plant after it is completed, and that after the works are completed, interest should be figured until the product of the plant is fully marketed. We have also carried out your instruction to use the unusually low selling price of 1.2 mills per kilowatt-hour for the secondary power and 4 mills per kilowatt-hour for the primary power at the low-tension busbars of the generating station, in order that Congress may always be certain that the final results will fully justify the money to be here invested.

Under your instructions we have figured that the plant when completed must earn 5 per cent for interest and 5 per cent for depreciation and operation, or 10 per cent of the cost of the power end of the enterprise. Both of these assumptions are conservative. The kilowatt-hours in Paragraph 2 multiplied by the selling prices in Paragraph 4 will produce a gross annual income of $4,554,000, which is 10 per cent of a cost price of $45,540,000. The best estimate that can be made at this time of the total cost of the project, including the two lift locks and all of the navigation facilities is around $50,000,000, and thus leaves about four and one-half million dollars as the amount applicable to the navigation account.

All the above quantities are accurate and are not to be considered as assumptions or approximations. The values for the secondary and primary kilowatt-hours are about 50 per cent of pre-war steam costs in the territory under consideration.

## Gas Burner Saved Money

By A. C. McHugh

The boiler plant supplying a small institution with steam for heating, cooking, laundry use, etc., is equipped with two boilers each of 1,600 sq.ft. of heating surface, and as the load is small one boiler is sufficient to carry it. The operating time is from 12 to 16 hours per day, according to the season, as it is necessary to run longer during the winter months so as to take care of the heating load. Fuel oil, costing in 1919 approximately $1.60 per barrel was used as a fuel, and from 8 to 13 barrels per day were consumed, according to the load and the length of the run. As the plant is near a large natural-gas producing oil field, it was found possible to make a contract for natural gas, piped to the plant, at 20c. a thousand feet; so it was decided to install gas burners, as the prospects of making a considerable saving over oil were very good. Natural gas at 20c. a thousand feet when used as a boiler fuel, will equal in cost oil at a dollar a barrel.

After considerable agitation the engineer was allowed $160 with which to pipe and equip the two boilers with gas burners. With this small allowance it was impossible to buy patent burners, so burners were made

up at the plant. Detail of the burner is shown by the lower view of the illustration. The furnaces are 7 ft. wide, and by taking off the two doors and placing the burners through these openings, 16¾ in. apart and the same distance from the side walls, it was possible to use four burners in each furnace. The ends of the burners were extended in, flush with the inside of the front wall, and the doorways around them were bricked up. The door frames were drilled and tapped for machine screws, and sheet-iron plates were fitted to prevent air leaks and also to improve the general appearance of the boiler front.

The oil burners were of the front-shot type located at the rear of the furnace. These were removed and the ashpits sealed. A firebrick checkerwork wall about three feet high was built, extending in a slightly crescent-shaped line across the furnace, the ends being approximately 3 ft. from the ends of the gas burners (or the front furnace wall) and 8 in. from either side wall, while the center bowed away about 10 in. The object of this wall is to break up the gas and air coming from the burners, giving the two a chance to mix properly. Its incandescent surface also aids combustion. A 2½-in. pipe was used between the meter and the boilers, a distance approximately of 90 ft., and as it was necessary to use nine elbows in the run, it was thought best to carry 3 lb. gas pressure in order to supply the maximum demand. But it was found that by using a length of 3-in. pipe as a reservoir, or sort of receiver across the boiler fronts to which the burner headers were connected, the pressure was so improved as to permit a reduction to 2 lb. at the meter.

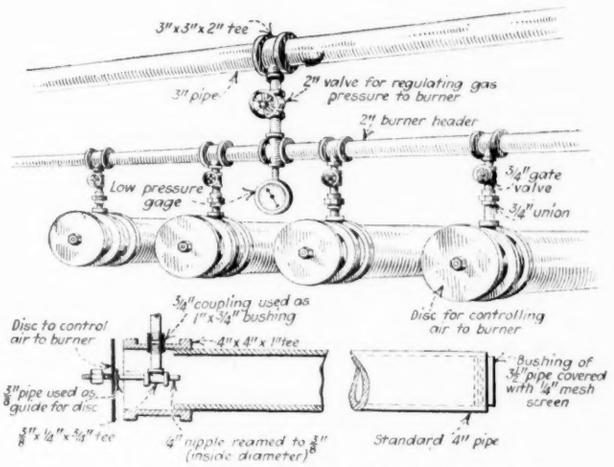
### How the Fire Is Controlled

To control the fire when the load is near full boiler capacity, the main 2-in. valve to the burner header is used as a throttle, but on lighter loads one or more burners are shut off, as it was found that the $CO_2$ in the flue gas could not be readily controlled when a very low gas pressure was used. A small pressure gage, connected to the header, is of great assistance to the fireman, as it enables him to adjust the discs which control the air to the burners and also helps him determine the proper damper setting. The top vein of the illustration gives an idea of the general piping on the boiler fronts.

Reference marks on the damper-control rods are used in setting the dampers for various changes in gas pressure and the number of burners in use. It has been found, when checking up with a flue-gas analyzer, that this method gives good results. Flue-gas analyses, under the best conditions, give a $CO_2$ percentage of from 8.5 to 9; oxygen 1.8 to 2 per cent, with CO varying from nothing to a very slight trace. There is no information at hand as to the constituents of the natural gas, but evidently it is very high in hydrogen, as the heat value is high and the flue gas drawn off for analyzing is so moist that the waste used as a strainer in the aspirator tube had to be removed, as it became so wet in a short time that it prevented the passage of gas to the bulb.

The short piece of 3½-in. pipe shown in the end of the burner is used to prevent the fire burning back into the burners on low gas pressure. The bushing naturally increases the velocity of the gas entering the furnace, by reducing the area of the burner. However, when firing heavily, it was noticed that combustion did not take place at the end of the burners at all times, but would work back and forth between the checkerwork and the burners. This was especially true when first starting fire as, aggravated by a cold furnace, the pulsations took the form of puffs so severe as to lift the explosion doors in the boiler setting. Choking down on the damper and the discs controlling the air to the burners helped considerably, but did not help the economy, so it was decided to cover the ends of the burners with ½-in. mesh screen. This has proved a satisfactory remedy, as now the flame never leaves the burner tips. The air and gas, passing through the screen keep it cool so that it is not affected by the furnace temperature. No soot is deposited upon the heating surface of the boiler, and but a small amount of very fine gray ash accumulates on the tubes.

The plant has no feed-water or steam-flow meter, and no evaporation tests were ever run, but a very good idea as to the saving effected can be obtained by comparing the gas used each month with the oil used during the corresponding months of the year before. Gas was first used in November, 1919, and comparing the five months' period, November, 1919, to April, 1920,


3"x3"x2" tee
3" pipe
2" valve for regulating gas pressure to burner
2" burner header
Low pressure gage
¾" gate valve
¾" union
¾" coupling used as 1"x¾" bushing
Disc for controlling air to burner
Disc to control air to burner
4"x4"x1" tee
⅜" pipe used as guide for disc
Bushing of ¾" pipe covered with ¼" mesh screen
⅜"x½"x¾" tee
4" nipple reamed to ⅜" (inside diameter)
Standard 4" pipe

DETAILS OF GAS BURNER AND THE PIPING ARRANGEMENT

when gas was used as a fuel, with the five months' period, November, 1918, to April, 1919, when oil was used as a fuel, gives the following results: Gas, 8,080,253 cu.ft., cost at 20c. a thousand feet, $1,616.05; oil, 1,939 bbl., cost at $1.60 per bbl., $3,102.40; a difference of $1,486.35, or approximately $9.78 per day.

Considering the fact that the demand for steam in 1919 and 1920 had increased considerably over that of 1918 and 1919, the saving was greater than is evident from the comparison. On the other hand, however, it should be admitted that several improvements were made in the operating methods and a closer check on leaks, etc., was kept during the period that gas was used than when oil was fired, but still the balance is very decidedly in favor of natural gas as a fuel, especially at the present time, when fuel oil in this locality is quoted at $2 per barrel.

---

A new twin-screw Diesel motor ship, built to the order of the Oestasiatiske Kompagni, was launched Feb. 7 at Burmeister & Wain's yard on Refshale Island. The new vessel is to be fitted with two Diesel motors developing together 4,500 hp., and a speed of over 12 knots is anticipated.

# Cooling of Cylinders and Pistons of Marine Diesel Engines

By LOUIS R. FORD

ONE of the fundamental problems involved in the operation of any type of Diesel engine is the disposition of the heat that is evolved by burning the oil in the cylinders, and the control of the resulting temperatures in the engine parts that are in contact with this heat. The heat distribution and temperature control are primarily problems for the designer, but even in a correctly designed engine they are also problems for the operating engineer. Conditions under which the engine operates may change and these conditions may at times be such as the designer never contemplated.

Considering the fact that when the fuel burns in the Diesel-engine cylinder the resultant gas may reach a temperature of 3,000 deg. F., which is above the melting point of the metal of which the cylinders, cylinder heads and pistons is made, the importance of cooling these parts may be appreciated.

The maximum heating effect due to the combustion of the oil is exerted over a small portion of the metal surfaces, because the maximum temperature occurs during the short period of combustion, at which time the piston is near the top of its stroke and the cylinder volume in which this combustion takes place is very small. The amount of cylinder-wall surface that is exposed to direct action of the heat during combustion is so small as to be negligible, but the whole surface of the under side of the cylinder head and the top of the piston receive the full heating effect of the burning gases at the time when their temperature is highest. The cylinder heads, and to a less degree the piston, are necessarily complicated castings, and they must sustain the maximum pressure that occurs in the cylinders. This combination of high temperature, high pressure and complicated form of casting makes the proper cooling of these two parts of the engine structure of prime importance in operation. The other parts that must be cooled are the cylinder liners, exhaust valves, air-compressor cylinders, air-compressor intercoolers, crosshead guides, and sometimes the exhaust manifold.

**One of the difficulties encountered in the operation of marine Deisels is with the cooling water system. The author points out the precautions that should be observed and discusses the basic defects in those instances where cylinder-head and piston failures have occurred**

On seagoing vessels salt water drawn from the sea is used as a cooling medium for all parts of the engine except, in some cases, the pistons. For reasons that will be discussed later, the pistons are cooled with fresh water or oil, but with a correctly designed engine it is possible to use sea water for this purpose thus greatly simplifying the cooling system.

## Salt-Water Cooling

In a typical marine Diesel-engine installation for a moderate cargo vessel the course of the cooling water through one engine is as follows: The water is taken from the sea by a centrifugal pump and discharged into the main circulating pipe. After passing through the air compressor and intercoolers, it is led to the main cylinder jackets. The water then flows through the head to the exhaust manifold. From the exhaust manifold jacket it is discharged overboard through a sea connection. This constitutes what is designated the closed cooling system.

The intercoolers between each stage of the compressor are supplied with water through branches leading from the main line. The water enters the bottom of the intercoolers and rises to the top, whence it is discharged into the main line again. In some cases it has been found that this arrangement does not provide a sufficient flow of water through the intercoolers, and it was necessary to make the intercooling system an open system and discharge the water into the engine-room bilge.

In a similar way a branch from the main line supplies water to the crosshead guides, the water entering at the bottom of each guide and flowing out through a pipe at the top, either into the main line again or into the bilge.

On some motorships now in service it has been found that passing the main body of the cooling water through the air-compressor cylinder jackets, with branches leading to the intercoolers, is not a satisfactory arrangement. With installations of this kind the large volume of water passing through the air-compressor cylinder jackets cools the cylinder walls to such an extent that most of the moisture that is deposited out of the air separates out in the cylinders, where its presence is very undesirable. If the cooling system is arranged so that the air-compressor cylinders are cooled only enough to prevent dangerous overheating and most of the cooling of the air is done in the intercoolers, all of the precipitation of moisture will occur in the intercoolers and the water can be blown off through the intercooler drains. The logical arrangement, then, is to pass the main cooling water through the intercoolers and have branches to the compressor-cylinder jackets.

In the case of engines in which sea water is used for cooling the pistons, a small header branches off from the main supply pipe and it in turn has branches leading into each piston. The return water from each piston flows into a header, and this header discharges into the engine-room bilge. The reason this system discharges into the bilge is that the discharge from each piston is arranged to flow into a funnel on the discharge header so that the operator may observe the flow from each piston and test the temperature by feeling; consequently only atmospheric pressure can be carried on this line.

## Oil-Cooling Systems

On engines whose pistons are cooled with fresh water or oil, the system is a closed one and positive circulation is secured by means of a separate pump. A cooler is

placed in the circuit so that the water or oil that is heated inside the pistons may be cooled before it is again pumped through the system. A variation in the case of oil-cooled pistons is to discharge the hot oil from the pistons into the crankpits, where it mingles with the lubricating oil and passes into the sump tank.

### Using Lubricating Oil for Piston Cooling

Formerly, oil was the only cooling agent used in pistons, the reason for this being the difficulties experienced in preventing leakage of the cooling fluid into the crankpins and into the lubricating oil. Practically all lubricating oils available were compounded oils, and water leaking into the lubricating system formed an emulsion from which it was very difficult to separate the water. This emulsion quickly clogged the lubricating system. This led to the simple expedient of using a portion of the lubricating oil to cool the pistons. This method is in use on many trunk-piston engines using forced lubrication, a portion of the oil forced to the piston pin being led through a passage into the piston and after passing through the piston, being discharged into the crankpit, as in Fig. 1. The objections to this system are that the heat conductivity of the oil is rather poor, the heat of the piston sometimes causes the oil to carbonize and the carbon impairs the lubri-

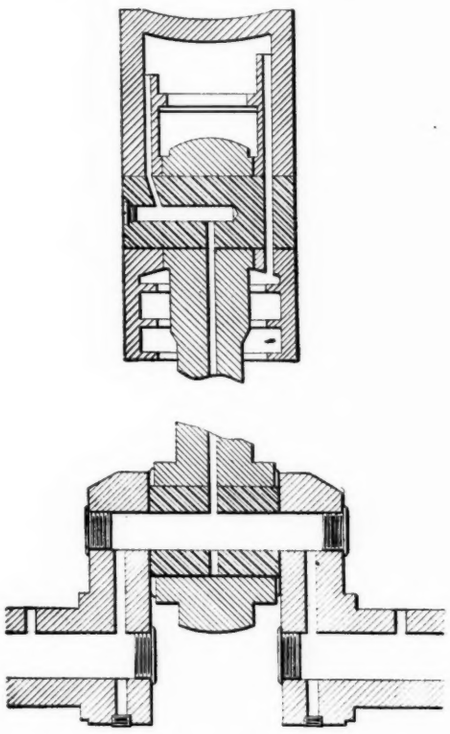


FIG. 1. PISTON COOLING BY OIL

cating qualities of the oil and clogs the passages in the system, and the supply of oil to the pistons may become insufficient, owing to loss of oil through the ends of bearings that have too much clearance.

The operator of engines using this method of cooling should be constantly on guard against trouble from these last two conditions. The writer has experienced persistent bearing trouble with a certain make of engine and this trouble was finally traced to the clogging of oil passages by flakes of carbon formed on the inner side of the piston top and flushed into the lubricating system. In the case of a group of engines of another make constant trouble was experienced from cracked piston heads. The pistons were dished on top and the cracks invariably occurred in the center of this dished top, the metal cracking in much the same manner that muddy ground cracks when dried by the sun. Examination of the pistons revealed that the outlet pipes extended only a short distance into the piston so that the oil flowed out without filling the piston, allowing the portion of the piston head directly under the spray valve to become overheated, as appears in Fig. 2. The outlet pipes in all the pistons were changed so that they extended into the pistons to a point close to the under side of the piston top. No oil could flow out until the piston was full and contact between the oil and piston top was assured. After this modification no more pistons cracked. In passing it may be remarked that these cracked pistons were made serviceable by boring out the cracked center of each of the piston tops and closing the hole by screwing in a plug and welding it in place. Water is a much more effective cooling medium than oil, but even with a "straight" mineral-oil lubrication difficulties are experienced if salt water is allowed to mix with the oil. The oil will form an emulsion with fresh water, but the water can be easily settled out. For this reason some marine engines are equipped with fresh-water piston-cooling systems. Usually, one of the double-bottom tanks is used as a fresh-water reservoir, a special pump forces the water through the pistons, and after leaving the pistons it is passed through a cooler before being used again. This cooler is usually constructed on the surface-condenser principle, and salt sea water is circulated through it to cool the fresh water. For this reason the water in the piston-cooling reservoir should be tested periodically for chlorine. The presence of salt water, as indicated by an abnormal chlorine content, calls for an immediate examination and test of the piston-water cooler for leaks.

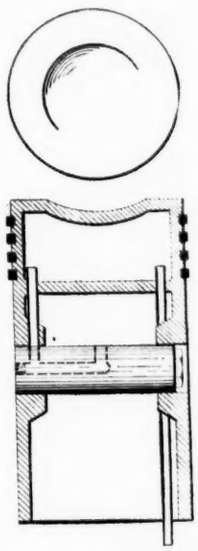


FIG. 2. DEFECTIVE PISTON COOLING

### Effect of Too Much Water in the Oil

The piston cooling water is conveyed through telescopic tubes, Fig. 3, or swivel-jointed pipes to the moving pistons. It is practically impossible to keep these tubes on flexible joints absolutely tight for any great length of time, and in the case of engines having this piston-cooling piping arranged inside the housing, so that any leakage falls into the lubricating oil, the operator must be constantly on guard against excessive amounts of water in the oil. It is good practice to install a pump-suction connection in the bottom of the lubricating-oil sump tank so that water settling to the bottom of the tank may be pumped out. If on a long voyage the leakage of water into the oil becomes very bad, enough water may collect in the sump tank to raise the oil above the level of the suction of the lubricating-oil pump. When this occurs, the pump will force only water through the lubricating system and into the bear-

ings. A separator of the centrifugal type is a great aid in rapidly removing water from the oil, but in the absence of such a device a tank should be provided, fitted with a steam coil, into which the lubricating oil may be pumped when the ship is in port, heated and allowed to stand for several days to permit the water to settle out.

It has become general practice on large marine Diesel engines to so design the cooling system that there are no joints inside the housing that may leak and allow water to get in to the lubricating oil. With a design of this sort it is possible to use sea water instead of fresh water for cooling the pistons. This is a desirable arrangement as it obviates the necessity of carrying a large amount of fresh water, does away with two cooling-water pumps and the water cooler with its piping and, as previously explained, makes the piston-cooling system simply a branch of the main cooling system of the engine.

If the design of the engine is such as to eliminate all danger of water leaking into the lubricating oil, the only troubles to be looked for that may be charged to the use of sea water are deposit of scale and solid matter in the pistons and corrosion of the metal parts in contact with the water. These objections, however, are outweighed by the simplicity of the all-sea-water cooling system for the whole engine.

### Cylinder-Head Cooling

The proper cooling of cylinder heads involves, first of all, correct distribution of metal in the head to facilitate transfer of heat from the metal to the cooling water, and if correct metal distribution is not provided for in the design, the operating engineer can do little to avoid cracked heads. The operator's chief concern must be the prevention of air pockets in the heads and the maintenance of a steady and adequate flow of water. Air, being much lighter than water, will accumulate in the highest part of the cooling system and in any unvented pockets in the circuit. In numerous cases cylinder liners have cracked near the top of the cylinder because the water passages between jacket and liner were placed below the highest point in the jacket. This permits air to collect in that portion of the jacket above the outlet passages and prevents any water coming in contact with the metal of the liner right at the point where cooling is most necessary. At this point the metal of the liner is thickest and the amount of heat to be transferred is greatest. The best way to prevent the formation of air pockets at this point is to pass the water from the jacket to the cylinder head through cored holes at the top of the jacket. If overheating persistently occurs at this point, the engineer should study the construction to determine the possibility of air collecting here.

Air cocks should be installed at the highest point on each cylinder head, and the operating routine should provide for venting these cocks at regular intervals. Normally, there is always some air present in the water, but if an excessive amount is blown out of the air cocks it indicates a leak somewhere in the system. Leaks sometimes occur in the compressor intercoolers, owing to corrosion or fracture of the tubes or coils, and air will be blown into the cooling water. Excessive amounts of air blown out of the cocks may also indicate the existence of a crack in the cylinder head, through which the air and gases from the cylinder are blowing into the water space in the head.

The amount of water flowing through the cylinder jackets and heads should be regulated by a valve placed in the outlet from each cylinder. If such valves are not provided, the engineer should have them installed. If the water is regulated by adjusting valves in the inlet line, there is danger of cutting down the water to the point where so little is flowing into the jackets that the jacket space may not be entirely full. On the other hand, if the inlet valves are wide open and the outlet is regulated, the jacket space will always be full, no matter how low the rate of flow through the jacket may be.

No wrought-iron or steel piping should be used anywhere in the cooling system. Sea water at normal temperature is highly corrosive and when its temperature rises, as it absorbs heat from the engine, this corrosive tendency is very much increased. Only copper and brass pipes and fittings should be used, excepting in the case of large mains, which may be of cast iron, where weight is not a consideration.

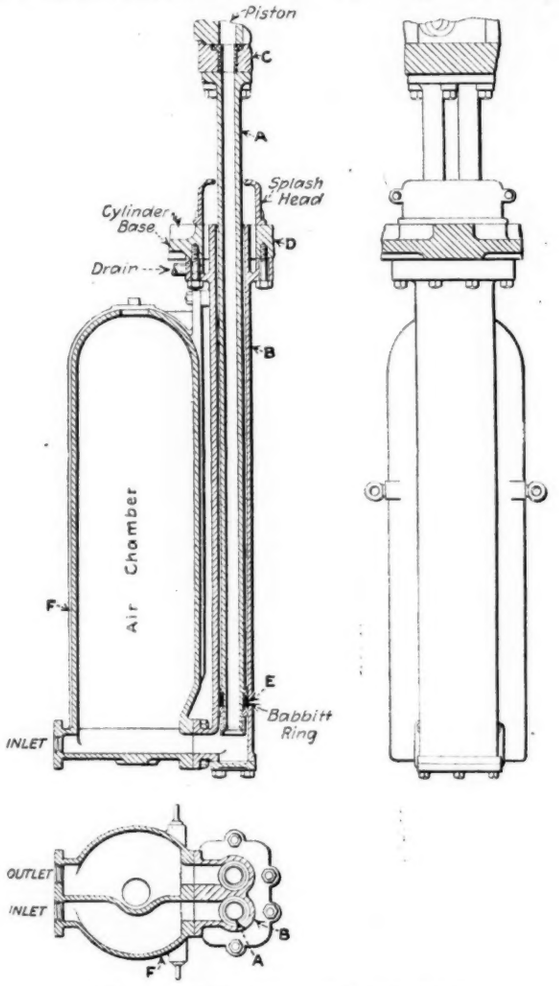



FIG. 3. TELESCOPIC COOLING PIPE

### Operation Precautions To Be Observed

Practically all water carries some solid matter in suspension, and in the case of sea water this solid matter amounts to 1 lb. in every 32 lb. of water. When the water is heated, this solid matter settles out in quantities depending on the temperature. The solids in sea water consist mostly of scale-forming matter, and after an engine has been in use for a time there is likely to be a coat of scale deposited inside the pistons,

cylinder jackets and heads, its thickness depending on the time the engine has been in use, the temperature of the water and its velocity through the system. This scale is a poor conductor of heat and acts as an insulator between the metal surfaces and the cooling water, causing the metal to become overheated.

The cylinder jackets and heads are usually provided with handholes through which sediment and scale may be removed. The piston can be cleaned by removing it from the cylinder and disassembling. The cooling-water temperatures ordinarily reached in practice are not high enough to cause much of the scale-forming ingredients to settle out, but a surprising amount of sediment is deposited by water that looks very clean. During the shop test of a large Diesel engine, conducted by the writer, cooling water was taken from the city mains, and in appearance this water was perfectly clear. When the cylinder heads were opened up, after over 300 hours of running, handfuls of muddy sediment were taken out.

When the engine is shut down, the circulating-water pump should under no circumstances be shut down until all parts of the engine are thoroughly cool, for if it is the large amount of heat stored in the metal of the cylinders, heads and pistons may heat the water in the jackets beyond the boiling point and all the hard scale-forming matter will settle out. In the case of trunk-piston engines, if the cooling water is shut off too soon, the heat will travel down the piston and it is possible for the piston pin to become so hot that all the oil in the bearing will be burned out, so that, when starting up, the bearing will be ruined before more oil reaches it. If the engine has an attached circulating pump, an auxiliary pump should be provided for use when the engine is shut down.

In considering the temperature at which the cooling water should be kept when running, it should be understood that the heat flows through the metal from a point of high temperature to a point of low temperature just as water flows from a high point to a low point. Passing cooling water through the jacket space is simply a means of maintaining a temperature difference between the fire side and the water side of the metal. As far as any injury to the metal by heat is concerned, it is quite feasible to allow the cooling-water temperature to reach the boiling point, but other considerations render this inadvisable. Hot cylinder walls, cylinder heads and pistons improve combustion conditions in the cylinder, but heating must not reach the point where expansion will cause the piston to seize in the cylinder or the piston ring to become tight in the grooves. As stated previously, the higher the temperature of the water the greater the liability to scale troubles. No one temperature for the discharge-water should be maintained all the time, as the temperature of the inlet water varies with the location of the ship. On a single voyage the temperature of the sea water may vary 20 deg. F. As a general rule the temperature of the discharge water leaving the cylinder heads should be 40 to 60 deg. F. higher than that of the inlet water. With pistons this difference should be 30 to 40 deg. F.

It is of the utmost importance to guard against sudden changes in temperature, especially in the cylinder heads, where rapid expansion or contraction may set up stresses that will cause the head to fracture.

All thermometers in the cooling-water lines should be examined to make sure that they are located correctly. A thermometer may be screwed into the top of a tee in such a position that its stem does not touch the water flowing in the pipe, consequently it may register a comparatively low temperature when the actual temperature of the water is dangerously high. It is good practice to have a small pipe running from each cylinder-head outlet to a funnel at the operating platform so that the engineer can at all times note the flow and feel the temperature of the jacket water.

# Effects of Sulphur in Coal

By ALEXANDER D. BAILEY*

THE presence of sulphur in coal, particularly as it is found in the Middle West, has been recognized for a long time as one of the chief sources of trouble in handling. It not only plays a large part in determining the life of mine, railroad and power-station equipment, but it also affects storing, owing to the liability of spontaneous combustion.

Railroad men have estimated the life of the ordinary steel gondola car at six years, due to the corrosion of the side sheets, stakes, bottoms and framing, and while this average life may be increased by using heavier materials, it can be done only at enhanced cost, which must be directly charged to the same source as the repair of the cars under the previous condition. The composite type of car is coming into favor largely for this reason, as the wood sides and bottom do not suffer from this deterioration and serve to protect the steel framing, which is first coated with acid-resisting paints.

Probably, however, the greatest damage due to this ingredient of the coal is in power plants, and every reduction of heat loss in the boiler room, with consequent gain in efficiency, is partly offset by the increasing cost of maintenance. It has been realized for a long time that unlined steel stacks are subject to rapid corrosion, particularly where the moisture content of the coal used is high and where the boilers are fired intermittently, so that the uptakes and stacks have an opportunity to cool. So long as the temperatures are high little damage is done, and in consequence the boilers themselves, when properly taken care of, generally show little effects. Emphasis should be placed on the phrase "properly taken care of," as leaks around the heads, tube headers, superheater headers and the like, result in a collection of flue dust and the consequent forming of acid, which soon corrodes the plates and tubes on which it collects.

Boilers that are fired intermittently and are not kept clean on the external surfaces will likewise be found to be badly corroded in time, owing to the affinity of this ingredient of flue dust for moisture and the resultant acid formation.

Piping, not only about the boilers and the coal-handling equipment, but even buried in the ground in the vicinity of coal-storage piles, likewise suffers if not protected by paints or in some other manner, from similar action. It has been found that the water draining from coal-storage piles and filtering down through

*Chief Engineer, Commonwealth Edison Company.

the ground is sufficiently strong to rapidly corrode pipes buried four and five feet below the surface.

Coal unloading and conveying equipment creates another point at which this ingredient can operate. In handling and burning this coal, it is generally advisable to wet it, which can be most effectively done at the time it is unloaded and before it is put in the bunkers. As a consequence we find receiving hoppers, coal conveyors and storage bunkers all bearing the marks of the action of this agent, and their life and usefulness are maintained only by continual care and at considerable expense.

If, in addition, this coal-handling equipment is required to handle ashes from this coal, the deterioration is that much more rapid. A malleable-iron conveyor handling coal and ashes has an estimated life of about seven years, after which it must be completely rebuilt, while partial rebuilding is necessary in about one-half this time.

### Deterioration Delayed by Rust

In the case of steel bunkers, where the movement of the coal on the plates is very slow, the steel protects itself by a heavy coating of rust, which delays the action of the corroding agent. The cleaning of the steel and the painting with ordinary paints only serve to hasten the deterioration as a fresh surface is supplied for the action of the acid.

Depending upon conditions, steel coal bunkers have been eaten through in from four to eight years, while the life of the spouts and chutes leading to the stokers is probably not greater than three or four years, and has been as low as the same number of months where the steel was unprotected. As a consequence it is becoming more and more the standard practice to protect this equipment, wherever possible, with a lining of some kind, so that it will not come directly in contact with the coal.

### Protecting Bunkers with Gunite

In the case of coal-receiving hoppers, coal bunkers, ash bunkers and the like, one of the most common methods of protection is to coat the steel with gunite, concrete shot on by means of compressed air, although many bunkers have been lined with concrete applied in the usual manner; also with vitrified tile set in cement mortar. The steel may or may not be first covered with an acidproof paint. Little can be done for the protection of conveying equipment, except to handle the coal as dry as possible, which prevents the accumulation of moisture on the metal.

Coal spouts have been effectively lined with tile or concrete, but as this is very heavy, wood has made a very satisfactory substitute, the steel being first protected with a heavy coating of acid-resisting paint.

Whether or not the presence of sulphur has a deteriorating effect on the furnace lining of a boiler is not clearly understood, as there are so many other constituents of the coal affecting this part of the equipment in addition to the high temperature and the abrasive effect of the gases.

### Economizers Subject to Attack

The installation of economizers to reduce the temperature of the stack gases has also afforded an additional point of attack, and the efficiency of the installation is materially reduced by the conditions imposed by this ingredient of the coal.

While it would be highly advisable from an efficiency point of view to take the condensate directly from the prime movers at a temperature of 80 or 90 deg. F. and pump it through the economizers, thus obtaining high temperature difference and consequent high heat transfer between the flue gases and the incoming water, the corrosion of the economizers themselves at the low temperatures thus induced prohibits this method, and it has been found instead that it is necessary to heat the water entering the economizer to about 140 deg. F. in order to prevent the wet, sooty deposit on the tubes and headers which soon corrodes them to the point of failure.

This applies to cast iron or semi-steel economizers, but in many instances where steel economizers are used, it is considered advisable to raise the temperatures still higher, to approximately 175 deg., which reduces the overall efficiency of this equipment just that much more.

### Cleaning Hastens Action of the Acid

Scrapers or other cleaning devices suffer a rapid and sure fate from the same cause, and the consistency of the deposit on the tubes renders their operation almost useless. The occasional cleaning of the metal surfaces with water or by some other means only hastens the action of the acid, as a fresh surface is supplied for its attack.

Under conditions favorable to the action of acid, economizer tubes have been reduced 30 per cent in weight within two years, and although this action is reduced at higher temperatures, it is not entirely eliminated. It merely continues at a slower rate.

The shutting down of this equipment also affords an additional opportunity for the action of this agent, as the sooty deposit on the tubes has a strong affinity for water, so that sulphuric acid is rapidly formed if the temperatures are sufficiently low.

Fan casing, runners, boiler and economizer uptakes and connections are all subject to the action of this corroding agent, and the collection of dust on the unprotected steel surfaces, while dormant at high temperature, takes advantage of each drop in temperature due to shutting down or for any other cause, to continue its destructive work.

### Action of Sulphur on Preheater

The much talked-of preheater, to be installed after the economizer and to be used for preheating the air entering the furnace, will be subject to the same fate and, because of the low temperatures under which it will run, will be particularly subject to the action of this constituent. As the heat transfer in this type of equipment is necessarily low, the surfaces will be correspondingly large and it will be an exceedingly difficult matter to protect the steel in any manner without seriously affecting its usefulness, so that it may be found necessary to give up this promising addition to powerhouse equipment, where the coal used has a high sulphur content.

With the present method of coal handling and power production from coal, the sulphur in coal leaves its mark at every step, and increases in equipment and refinements tending to increase the efficiency of power production only increase the field of its activities and its importance. Along with the other byproducts of the coal this ingredient has a value, and any process that will eliminate this persistent source of trouble and expense will be of interest to power-plant operators.

# Controllers for Alternating Current

THE two principal types of control that are used with elevator motors are semi-magnetic and full magnetic. In the former the reversing is accomplished by a mechanically operated reversing switch; in the latter, by directional contactors controlled from a car switch installed in the elevator car. Generally, semi-magnetic control is not recommended for car speeds exceeding 100 ft. per min. The General Electric Co. has recently developed both types of control for use with slip-ring type and high-resistance rotor squirrel-cage type induction elevator motors.

### Control for Slip-Ring Induction Motors

Fig. 1 shows a typical four-point full-magnetic control panel for slip-ring type induction motor. The panel consists essentially of one safety line contactor *L*, two mechanically interlocked "up" and "down"

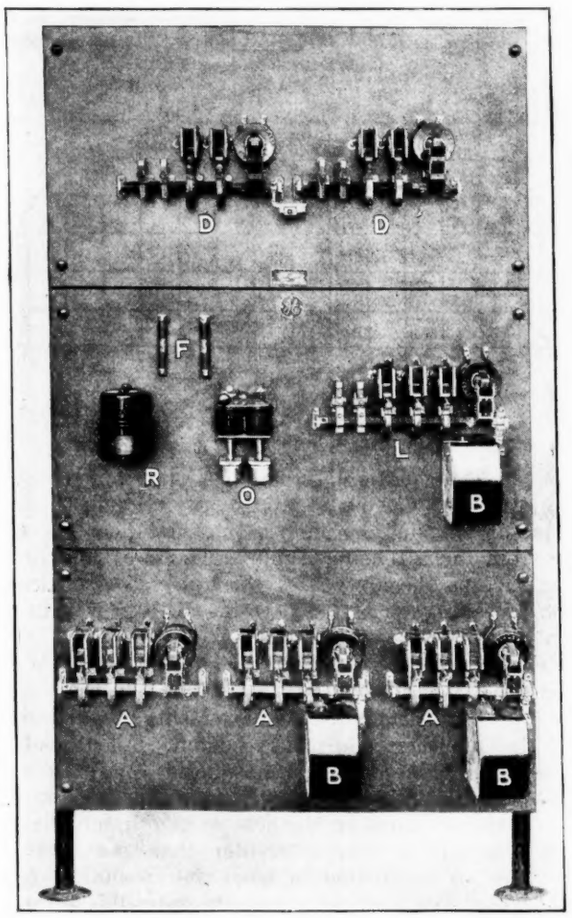



FIG. 1. FULL MAGNETIC ELEVATOR CONTROLLER FOR A.-C. MOTORS

directional contactors *D*, three accelerating contactors *A*, a hand-reset overload relay *O*, a reverse-phase relay *R*, and two control fuses *F*. The number of accelerating contactors will vary with the size of motors; namely, up to 10 hp. 3 points, from 10 to 25 hp. 4 points, and from 25 to 40 hp. 5 points acceleration are used.

The current peaks during acceleration of slip-ring motors are lower with light and average loads than they are with heavy loads, but in elevator work the heavy loads are the exception to the rule. If current-limit acceleration is employed, advantage cannot be taken of these lower accelerating peaks. In order to gain this advantage, time-element acceleration is employed. To obtain this given time interval between the closing of accelerating contactors a flywheel-type interlock *B* is

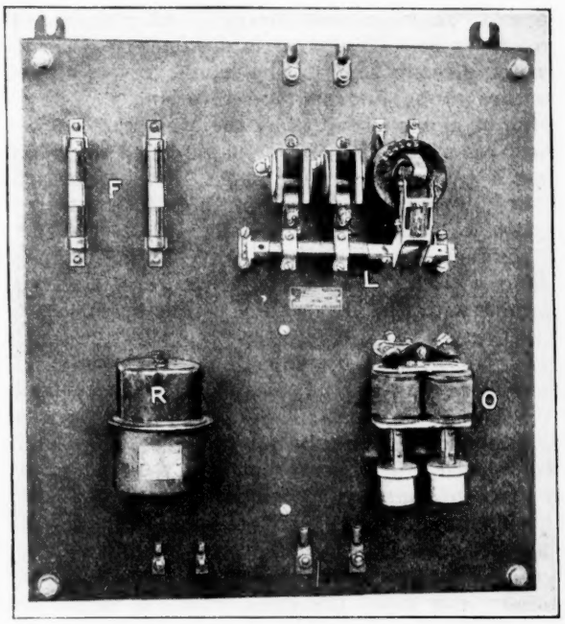



FIG. 2. SEMI-MAGNETIC ELEVATOR CONTROLLER FOR A.-C. MOTORS

utilized. This consists of an unbalanced free-moving flywheel which is released upon closing of the contactors on which it is mounted. This permits the interlock to function, causing next accelerating contractors to close.

Upon movement of the car switch to the first point either "up" or "down," the proper directional contactor function, causing next accelerating contactors to close. connecting the motor to the line with full resistance in the circuit. The closing of the safety line contactor releases the flywheel interlock mounted on it, permitting the first accelerating contactor to close, which releases the interlock, etc., until the motor has automatically accelerated up to full speed and is running with no resistance in circuit.

If for any reason the safety line contactor is accidentally stuck in the closed position, there are electrical interlocks so arranged as to prevent either of the directional contactors from closing until the safety line contactor is first free.

A reverse-phase relay *R* provided with potential coils is supplied on all polyphase elevator panels. This relay prevents starting of the motor in case of phase failure or phase reversal, provided the difficulty is not between the relay and the motor terminals. Practically all building codes call for a phase-reversal relay with potential coils on polyphase alternating-current elevator control panels.

The overhead relay *O* is of the two-coil inverse-time-element type and protects against sustained overloads,

but does not trip on the accelerating peaks. The overload relay may be omitted if not desired.

The semi-magnetic type of control panel is similar to the full-magnetic with the exception that a drum-type reversing switch is used instead of magnetically operated contactors for reversing the motor.

### Control for High Resistance Rotor-Type Squirrel-Cage Induction Motor

Fig. 2 shows a semi-magnetic control panel for a high-resistance rotor squirrel-cage motor. This panel consists essentially of a main line contactor *L*, a reverse-phase relay *R*, hand reset overload relay *O*, and two control fuses *F*. This panel is designed for throwing the motor directly across the line, the reversing being taken care of by a drum-type reversing switch. All breaking of motor circuit is by the contactor tips. The overload relay and the reverse-phase relay are similar to those described under control for slip-ring motors.

In the full-magnetic control for high-resistance rotor squirrel-cage motors, mechanically interlocked directional contactors are used instead of the drum-type reversing switch. These contactors are electrically interlocked with the safety line contactor, to prevent closing in case the safety line contactor is stuck.

There is, sometimes, objection to throwing the larger sizes of high-resistance squirrel-cage type motors directly across the line. Therefore, a line of panels giving two-point acceleration for this type of motor has been developed. The panel consists essentially of a safety line contactor, two mechanically interlocked directional contactors, and one resistance contactor controlled by a flywheel-type interlock mounted on the safety line contactor. On closing, the resistance contactor shorts out the resistor used in series with the primary at starting. This equipment often permits the use of squirrel-cage motors on elevators traveling at speeds from 100 to 150 ft. per min. These higher speeds would be undesirable if the motors were thrown directly across the line.

For elevator speeds above 175 ft. per min., and for slower speeds where accurate landing is required, a two-speed alternating-current elevator motor is often used. The control for such motors is generally of the full-magnetic type, incorporating the safety features already mentioned.

## Power Consumed by Dry Vacuum Piston-Type Pumps

By Merle A. Kolb

The power consumed by a dry vacuum pump of the piston type is a mystery to the average operator. But it is quite similar to an air compressor in its workings, the chief difference being in the initial and final pressures of the air handled. An air compressor draws air from the atmosphere at about 15 lb. per sq.in. absolute pressure into the cylinder and compresses it to possibly 60 lb. pressure. A vacuum pump draws air into the cylinder from the system being pumped out at a pressure of maybe only one pound per square inch absolute and compresses it to atmospheric pressure, at which pressure it is discharged to the atmosphere.

The power consumption of a vacuum pump running at a constant speed will, of course, vary with any change in the vacuum in the system being pumped out. Thus, when the vacuum gage reads 28 inches of mercury the power consumption is more than when it reads 29, because, assuming a 30 barometer, the amount of air compressed is greater.

The curve shows what theoretical horsepower is required at various vacuum gage readings by a pump that has a piston displacement of 100 cu.ft. per min. For a pump with any other displacement the power consumed may be found by direct proportion. The curve is based on the following equation, which gives the power required to compress a gas (air in this case):

$$W = P_1 \left(\frac{n}{n-1}\right)\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right]$$

in which

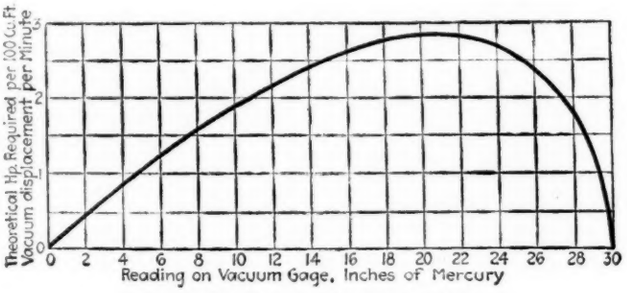
$W$ = Foot-pounds required to compress one cubic foot (at pressure $P_1$) of air from pressure $P_1$ to pressure $P_2$;

$P_1$ = Air pressure before compression in pounds per square foot absolute;

$P_2$ = Air pressure after compression in pounds per square foot absolute;

$n$ = Constant for air (1.406 was used).

In the present case $P_1$ is the pressure in the vacuum system being pumped out and $P_2$ is the atmospheric


Theoretical Hp. Required per 100 Cu. Ft. Vacuum displacement per Minute
0
1
2
3
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Reading on Vacuum Gage, Inches of Mercury

THEORETICAL POWER CURVE

pressure. The equation assumes the pump to be double-acting. It also takes no account of the friction between the moving parts of the pumps, or of any heat transfer to or from the air being compressed, or of any drops in pressure as the air passes through valves. Atmospheric pressure was assumed to be 15 lb. per sq.in. or roughly, 30 in. of mercury.

It will be noticed that, theoretically, no power is required when the gage reads 0 or 30. At 30 the piston meets no resistance against its movements because there is no air on either side of the piston. At 0 reading we have equal pressures (atmospheric) on each side of the piston. Between these two extremes 0 and 30, however, the pressure on the side of the piston that is compressing air is always greater than the opposite side, where air is rushing in from the vacuum system. The curve shows that at about 20 this difference is greatest because here the curve shows the highest power consumption.

The curve also shows why a vacuum regulator on a steam-driven vacuum pump is not worth while. For instance, if it is desired that a 28-in. vacuum be carried on a system and anything over this is considered unnecessary, then when it does get over 28, why not slow the pump down and save power? Because, as the curve shows, the power consumed really drops off rapidly as the vacuum gets above 28 and any slowing down of the pump would only increase the power consumption.

# Some Comments on Boiler Capacity

By L. R. LEE*

I BELIEVE it will be generally agreed that all water-tube boilers suitable for steam-electric generating stations of 25,000 kw. or more or boiler plants of 50,000 sq.ft. heating surface and over, are capable of being operated at "overrate capacity," disagreement existing only as to the extent that such operation is advisable and profitable. Furthermore, the peculiarities of different types are such that an overrating satisfactory for one type may be higher or lower than is advisable for another.

Steam pressure or temperature has little or no direct bearing on the matter of capacity, neither does the heating of feed water affect the output of the boiler itself, the economizer and feed-water heater being used to advantage in increasing boiler-plant capacities. Modern boilers carry pressures of 175 lb. and upward and steam temperatures of 475 deg. upward. The tendency is upward all along the line, including capacity, pressure and temperature. Although offset to some extent by operation at overratings, there has also been a tendency toward units of larger size, because of increased steaming demands, steam-turbine development and improved stokers. It is evident that the limits of capacity have not yet been reached, but a careful study may be required to show the advisability of high operating capacities. A rough approximation that may give a fair idea of the progress made is that average practice today is equal to the maximum practice of ten years ago. Thus 250 per cent rating, 250 lb. steam pressure and 550 deg. F. steam temperature are not far from a general average today. If history repeats itself, we may then expect 350 per cent rating, 325 lb. pressure and 700 deg. F. temperature as averages for some not far distant future period. All these latter figures are being obtained in a representative number of plants, but the question arises, Is it good practice in all cases, and what determines when it is good practice?

The following factors have done much to make high boiler capacities possible and practical:

*Boilers:*

1. Wider boilers with longer tubes allow large furnace volume with relatively small increase in brickwork exposed to fire.

2. Improvements in setting arrangements allow high and wide boilers to be set with all supports outside of furnace. Also improvements in supporting vertical walls.

3. Improvements in baffling and facilities for removing soot and fine ash.

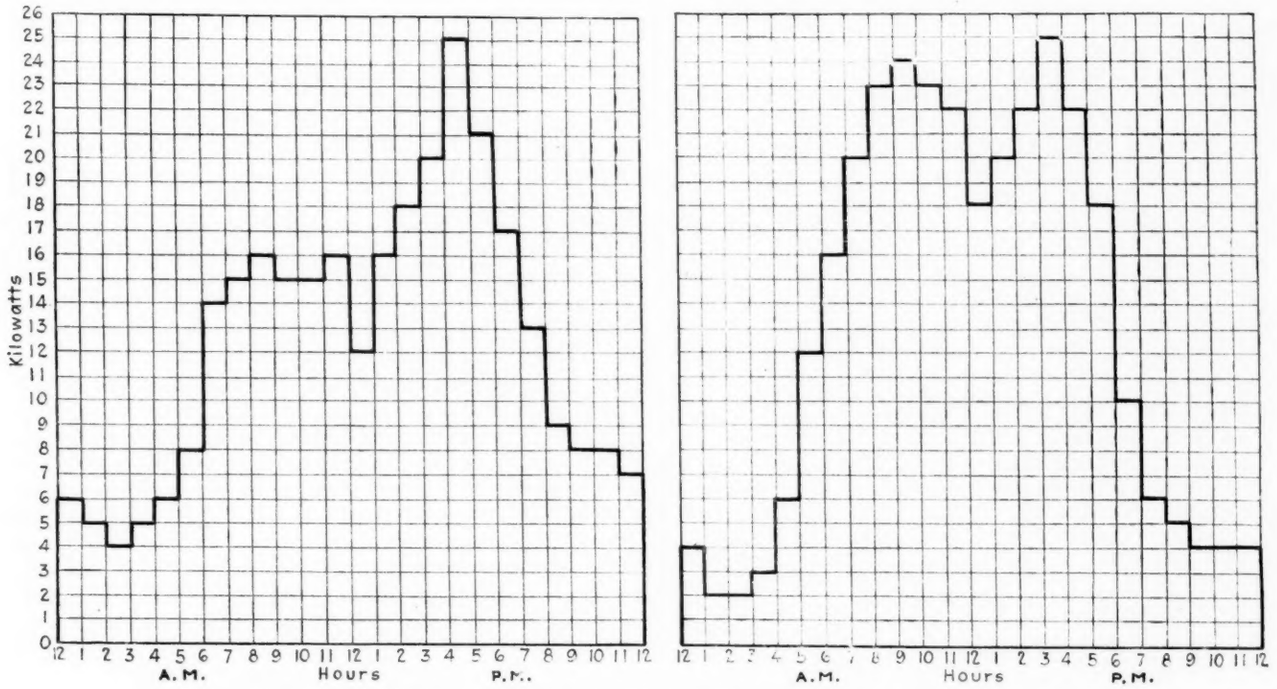



FIG. 1. TYPICAL LIGHTING AND POWER LOAD CURVES FOR 50 PER CENT LOAD FACTOR

*Stokers and Furnaces:*

1. Underfeed or forced-draft type allow great increase in coal burned per square foot of grate surface.

2. Improvements in stoker arrangements that allow stokers of great size to be operated at high capacities with low maintenance and operating costs.

3. Improvements that allow large quantities of low-grade coal to be burned with decreased labor for handling clinker and ash.

4. Large operating range, allowing high demand to be taken care of on short notice.

5. Underfeed type eliminates necessity for arches, effecting savings in plan area and brickwork maintenance.

*Draft Equipment:*

1. Development of high speed, high efficiency, forced- and induced-draft fans, allowing use of motor or turbine drive.

*Chief engineer, E. W. Clark & Co. Management Corporation.

2. Regulating equipment allowing proper draft to be automatically maintained.

3. Improvements in indicating, recording and graphic meters, enabling close check on furnace conditions.

*General:*

1. Steam-turbine development allowing use of high pressure and temperature with steady demand has done much to facilitate satisfactory delivery of steam for boiler.

2. Better grades of brickwork.

3. Recent improvements in oil burners.

4. General improvements which have made high boiler capacities possible have also improved efficiencies at all loads.

### What Is Meant by Boiler Rating

In speaking of boiler capacities or ratings, there are two terms which it is very important to consider—average rating and maximum rating. The maximum load on a steam-electric generating plant is usually referred to a time period of at least one hour, while the average is referred to a period of 24 hours, a month or even a year.

We have a habit of measuring load by maximum demand and load factor. Thus we may say a certain plant has a load of 25,000 kw. demand with 50 per cent load factor. This specification conveys considerable information, but from the boiler-plant viewpoint more information is required. If the maximum demand is sustained for only a short time, the boiler plant may be designed for high boiler rating without much regard for its efficiency at maximum load, whereas, if the maximum demand is sustained for a comparatively large portion of the time, then efficiency at maximum load must be considered. Therefore, it is important to know how long a time the maximum demand is sustained in determining the proper capacity in boiler plant. The two 24-hour load curves shown in Fig. 1 have the same load factor and maximum demand, yet they would impose vastly different conditions upon the boiler plant. The one for a lighting load shows a very sharp peak, covering, above 18,000 kw., a period of only three hours. It would seem from a careful examination of this curve that the point of maximum boiler-plant efficiency should not be above 15,000 kw. In the case of the curve showing power-load peaks the point of maximum efficiency could probably be raised to 20,000 kilowatts.

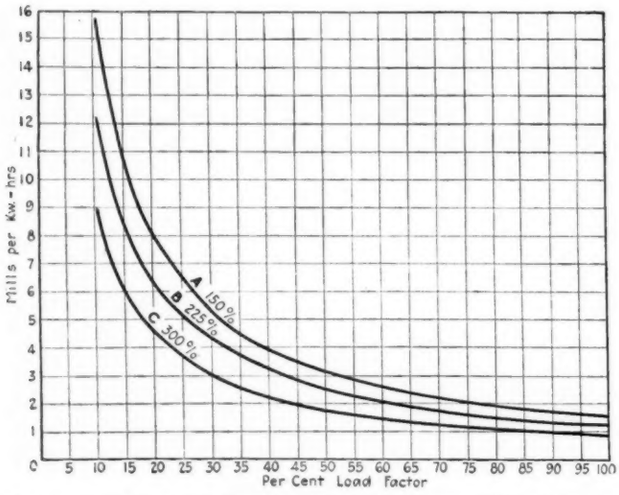



FIG. 2. CURVES SHOWING FIXED CHARGES FOR BOILER-PLANT OPERATION WITH RELATION TO INVESTMENTS AND LOAD FACTORS

The limits on boiler capacity are grate surface, draft, furnace volume, furnace height and quality of feed water. With these conditions satisfied almost any rating may be secured. However, it is not always easy to satisfy all these conditions without undue expense or inconvenience, which may offset all the advantages of high capacity. If sufficient grate surface can only be obtained by double-end stokers, then the expense of firing is increased and such a design may give indifferent results at low capacities. High settings involve brickwork which is difficult to hold in place and maintenance cost may be high. High draft encourages air leaks and calls for large fan capacity. High draft also requires careful design in gas passages, it being necessary to give special consideration to area of all passages so that velocities may not be too high and subject to sudden changes. Pure feed water would seem easy to obtain in a surface condenser layout with distilled makeup water being added as required. However, condenser leakage is not always easy to eliminate, and defects in condenser tubes may admit a quantity of bad water.

### Illustrating the Reason for Operating at Over-rating

The following example will best illustrate the principal reason for operating boilers at over rating: Desired a plant for a load of 25,000 kw. Assume that the plant will require 12.5 lb. steam per kilowatt-hour, boilers to supply steam at 250 lb. pressure, 600 deg. F. temperature. Boiler plant to be equipped with economizers and feed-water heaters; boiler capacity requiring (at 300 per cent rating) 115,000 sq.ft. of heating surface, therefore normal rated capacity in boilers 38,300 sq.ft. or, say, four 10,000-sq.ft. units. Assume that the plant investment will be $150 per kw. and that $52.50 of this is required for boiler plant proper. This figure is made on the assumption that the boilers are to be operated at 300 per cent rating when the plant operates at full capacity. If a greater capacity in boilers were installed so that it would only be necessary to operate them at 225 or 150 per cent rating, the cost of the boiler plant per kilowatt would be much greater, though probably not in proportion to the installed boiler capacity. A fair estimate of these costs might be $72 per kw. at 225 per cent boiler rating and $92 per kw. at 150 per cent boiler rating.

It is interesting to plot (see Fig. 2) the fixed charges per kilowatt-hour at various load factors for these three investments. A fixed charge of 15 per cent is assumed to cover interest, taxes and depreciation. These curves first of all emphasize the importance of high load factor and show the handicap of high investments. The saving made by the 300 per cent layout over the 150 per cent is 2 mills at a load factor of 34 per cent. This load factor approximates a load of 10 hours each working day. At 70 per cent load factor there is a saving of one mill or one pound of coal at $2 per ton. There are probably very few plants that operate on a load factor as high as 70 per cent, although there are occasionally plants used in connection with hydro-electric systems that have a very high daily load factor.

It should be noted that the boiler plant designed for high rating can operate at a much lower load factor without increasing the fixed charge per kilowatt-hour output. For example, curve *C* shows the 300 per cent plant may operate at 45 per cent load factor, 2 mills per

kilowatt-hour, while the 150 per cent plant would require an 80 per cent load factor to secure a rate of 2 mills. It would take considerable increase in plant efficiency to offset a handicap of this amount. However, if it is certain that the load will be high and that there will be no high peak loads to pick up frequently, then the high rating boiler plant has little to offer in fixed charge saving. At 80 per cent load factor it may be noted there is less than one mill difference between the 150 per cent and the 300 per cent plant. The 225 per cent plant would seem to fit such a condition best.

It may seem that too much emphasis is being placed, in this article, on determinations of boiler capacity by fixed charges. A good many have thought that high-rating loads meant high maintenance cost and were therefore undesirable. However, I believe that actual experience with high boiler overloads where the furnaces were designed for such operation have shown very satisfactory maintenance costs and have shown substantial savings in other operating items. I believe there have been more errors of judgment by installing too much boiler capacity rather than too little. There has sometimes been a gap between the intentions of the designers and the results obtained by the operators. For example, if to carry full plant load it is necessary to operate boilers to a maximum of 300 per cent, spare boilers will be kept in service, and a lower maximum boiler rating carried, thus interfering with cleaning and repairs.

We may, then, summarize on boiler capacity about as follows:

1. High load operation will show saving in fixed charges for low load factor, or where there is a high maximum demand of short time duration.
2. High load operation will not show a large certain gain for high load factor and low maximum demand.
3. A good compromise between an extremely high, and a too conservatively low rating would seem to fall on ratings that result in maximum efficiency near average load with other conditions, such as furnace height and draft equipment, such that short, high demands may be taken care of.

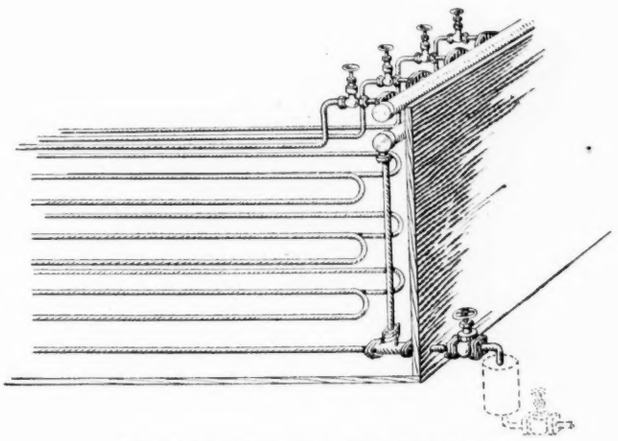
## Oil in the Expansion Coils

By F. L. Brewer

IN SUPPORT of the theory presented in a former article[1] that oil in refrigerating coils circulates with the ammonia and that only a small amount remains in them, the following cases are cited: A 25-ton ice-making plant was operated over twenty years and produced during the last fifteen years of the period over its rated capacity. The compressor was a vertical double-acting machine and was at all times copiously lubricated, it being the practice to pump about one pint of oil each twenty-four hours into the suction pump, in addition to the liberal use of oil in the stuffing box to lubricate the rod packing. The liquid ammonia was fed into the top of the coils, each coil having an individual expansion valve. A tee was used at the bottom outlet, and a vertical pipe connected this tee with a suction header located just under the tank top. A horizontal pipe connected into the run of the tee and extended out through the tank with a valve just outside for blowing out the oil. This method of oil removal was so well thought of that later, when an addition to the plant was necessary, the engineer, who had operated the plant during the greater part of its existence and who had been promoted to the position of manager, would not consider buying a tank that was not similarly equipped with oil drains.

These blowoff or oil drain valves were opened at intervals of about two weeks during regular operation, and while there was always some oil blown out, there was necessarily considerable loss of ammonia. To avoid this waste, reservoirs, consisting of 18-in. sections of 5-in. pipe, were attached to each valve, the connection being made at the top and at the bottom of the opposite end was the blowout valve. The original valves were left open until all frost disappeared from the reservoirs, an indication that they were full of oil, then they were cut off from the tank and emptied.

If oil in any considerable quantity had remained in the coils, this plant would have had no end of trouble, for the lubricant was liberally used. As previously



ARRANGEMENT FOR OIL DRAINAGE

stated, the plant operated successfully over a long period and the coils were never blown out in any other manner than as described.

A 25-ton high-speed compressor was installed to replace two 10-ton slow-speed machines. As it was anticipated that the high-speed machine would throw more oil over into the high-pressure side than had the old machine, the engineer was cautioned by the erecting man about blowing the oil separator oftener. Evidently, the instructions were forgotten, for in about three weeks there was a hurry-up call for a trouble man. When the erector got back on the job, the engineer explained that it was impossible to keep the goosenecks frosted and that it was one man's job to keep the expansion valves feeding. In answer to the queries of the erector regarding the blowing of the oil trap, he frankly admitted that this had not been done until the trouble started. He further explained that he could not keep the temperature down and that unless something was done quickly he could not get out over one-half the capacity of the tank. Knowing that a good grade of "zero" oil had been used, the erector first had the oil trap thoroughly blown out, then with the machine running, all expansion valves were closed and the suction pressure reduced to 15 lb. The expansion valves were then opened wide for a few seconds, one at a time, and the coils were in this way pretty well cleaned of the oil. Of course it was at times necessary to wait between the opening of the different valves until the suction pressure was sufficiently reduced to avoid getting liquid over to

[1] *Power*, Jan. 11, 1921, p. 71.

the machine. The operation of opening wide and then entirely closing each valve was repeated until there was no further tendency for them to stop working, the oil separator in the meantime being kept drained. While this method may not have purged thoroughly the system of all the oil, enough was removed so that at the end of 24 hours the tank temperature was down to 10 deg. and the tank producing over its rated capacity.

The foregoing method was successfully used in eliminating the oil from the ammonia system of a plant that had been remodeled and the tank coils blown out with steam and air five months previous to the changing of engineers. Noticing evidences of oil in the system, the new chief inquired how often the oil separator had been drained. The operator's reply was to the effect that he had several times tried to blow out the oil, but that there did not seem to be any oil in the trap. As two rather large machines, copiously lubricated, were discharging into the trap, the new chief reasoned that there was surely some oil being caught by it, so he at once tried the blowoff himself and to his surprise ammonia issued from the end of the pipe. After closing the valve and studying the matter over, his decision (which was later demonstrated to be correct) was that all the condensation had not been taken out of the coils at the time that they were blown with steam, or that water had entered from the water jackets when the heads were removed. Acting on this diagnosis of the case, he again opened the valve, and after discharging about a gallon of weak liquor, a 200-lb. ice can was filled about two-thirds full of oil. The separator was full up to the discharge line.

Many plants have storage rooms cooled by direct expansion, which are fed from the same line that supplies the coils of the ice tanks. It is a rare occurrence for the coils in the rooms to be disconnected and blown with steam or air. All things considered, it would be just as necessary, from the writer's point of view, to blow one as the other, for if operated at the same suction pressure, the temperature will be the same, and if we take into consideration rooms that have their individual machines and operate at extremely low temperatures, such as sharp freezers and ice-cream hardening rooms, there is a favorable condition for a thorough installation of the coils if oil remained in them to any great extent.

To preclude the possibility of the wrong kind of oil being used for the lubrication of ammonia compressors, all tanks used for ice-machine oil should be plainly marked and all new attendants cautioned about not getting oil for this purpose from any other tank.

In all the foregoing it has been assumed that a suitable oil has been used exclusively and which ordinarily will not cause any serious trouble, even if used in excessive quantities. However, if any other oil has been used and its use escaped attention of the engineer until the valves and coils are in such condition that a blowing out, with the coils heated, is necessary, it would be much better to apply the heat externally by placing salamanders or steam radiators in the tank, which would have to be emptied anyway, than to blow them with high-pressure steam. With this method no moisture will enter the coils, and as the heat will be uniformly applied, there will be no danger of leaks caused by unequal expansion and contraction. After heating, blow with high-pressure air from a receiver that has considerable volume. An idle boiler would be fine for this purpose as, owing to its capacity, the intervals between the blowing of the stands would be shortened. Those who prefer blowing with steam should provide a double connection so that the air will follow quickly the steam before condensation occurs. After blowing, every joint should be gone over and the bolts drawn up, for while an air test may not reveal a leak, it is not an unusual occurrence for them to develop after the tank is back in service.

Referring to the suggestion in a former article that a surface skimmer or blowoff could be advantageously used for oil removal, the thought has probably come to the reader that this method would entail the loss of considerable ammonia. Not necessarily so, for the blowoff could be connected to a regenerator and the ammonia and oil saved, the latter to be filtered before being used again.

Finally, before attributing a falling off in the capacity of ice tanks to "oil in the coils," be sure that there is plenty of liquid in the receiver, that the suction pressure and evaporator temperature are right, that the compressor is actually working up to its displacement without leakage, that the brine is of the right density and circulating rapidly, that the ice is drawn regularly and uniformly throughout the tank and that the cans are being filled with water at the lowest possible temperature. Then in most cases the conclusion will be that the coils do not need blowing out.

## Need of Engineering Publicity

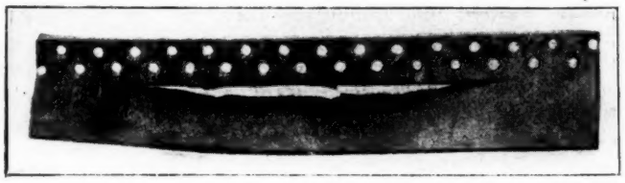
A conference on engineering publicity was held recently in Chicago under the auspices of the American Association of Engineers. The affair was a conference in fact as well as in name, for the participants, instead of listening to set speeches, gathered about a large table and discussed the subject of engineering publicity from all angles; over 60 per cent of those present actually entered into the conversation and practically brought about the condition of an open forum.

The consensus of opinion was that the engineering profession needs broad constructive publicity as an indispensable element of public service, and that a program must be decided upon providing for a national coordinating office from which information may be directed into the proper channels.

The American Association of Engineers has announced that it will incorporate the report of the conference in a pamphlet for the benefit of other societies and its own local chapters.

## A Harmless Boiler Failure

The illustration shows a sheet from the mud drum of a Stirling type boiler which recently failed in service without causing any damage whatever outside of the boiler itself. The boiler, which was twenty-nine years old, had 3,500 sq.ft. of heating surface and was being operated at 150 lb. pressure. Without any warning the fireman noticed that the water was low, and after the fires had been pulled an investigation showed the rupture of the mud-drum sheet, which was $\frac{11}{32}$ inch thick.



# EDITORIALS

## Providing for Publicity

IN PRESENTING to the United States Senate the results of its deliberations, the Committee on Manufactures under Senator LaFollette reported the so-called Calder bill with nearly all of the original sections stricken out and an entirely new document offered in its place. However, this substitute retains two of the important fundamental advantages proposed in the original bill. Essentially, the bill as reported to the Senate provides for securing "current publicity of information concerning the coal industry and trade," and secondly, arranges "to recognize and declare coal and its production and distribution charged with public interest and use."

No right-minded person who will fairly look upon the present situation or consider the experience of the past year can deny that coal is charged with the public interest. In matters of transportation and public-utility affairs, the principle has long been recognized that reasonable public regulation is proper, and indeed essential, to safeguard both the interest of the public and the property of fairly operated transportation and public-utility agencies. It seems strange, therefore, that there should be any serious consideration given to the argument that coal is not similarly a proper subject for public consideration and investigation. Despite all the fog that has been raised by such arguments, the Committee on Manufactures has kept this fact clearly in mind and has emphasized it in the proposed bill.

As a matter of fact, it is probably not the principle thus enunciated that is objected to. It is rather the fact that this is a possible entering wedge for legislation and investigation beyond that which the coal operators welcome which causes the attack upon the principle itself. If the existence of the Federal Trade Commission and its activities in coal-cost studies can be supported upon this new ground, then the coal operators and their association will likely find themselves much embarrased in any further prosecution of the suits to enjoin the gathering of coal costs. No doubt the case which now prevents the Federal Trade Commission from proceeding further in its work to this end would fall of its own weight. One can well understand, therefore, why there is the vigorous opposition to the recognition of the principle, but this fear and this opposition make the principle no less vital and no less true.

The public utilities long ago learned that cost accounting was of greatest benefit to themselves and have long ceased to oppose the idea of uniform systems of accounts. To be sure there still remains argument as to proper allowances for depreciation, obsolesence, amortization and other factors, but here again the principle of sound cost accounting has been recognized. The coal man is loathe to learn this lesson from the experience of the utilities. He does not know what his costs are and apparently objects to learning himself. Much more than this he objects to having anyone else find out. If the opinion of the Committee on Manufactures of the Senate ultimately prevails—and doubtless in due time it will prevail—the coal man will be compelled to keep costs accurately and upon a reasonable basis. When that time comes, he doubtless will learn, perhaps to his surprise, that this responsibility is not merely a handicap, but that it has attendant advantages to himself. But whether he will learn this lesson or not, he must come to recognize that the public is entitled to the facts.

## What Are We Going To Do About It?

TWO years ago fuel oil had become a drug on the market and many saw in it apparently a solution of the coal problem, which was acute. As a consequence, in the latter part of 1919 and the early part of 1920 a considerable movement was under way toward changing over from coal to oil burning under boilers along the Atlantic seaboard. Apparently, it required only such a movement to show how limited our oil resources are, especially as a source of fuel, since the increase of fuel oil under boilers in stationary power plants and in marine work soon created a serious shortage and the price went up accordingly. This has somewhat arrested the use of oil for land boilers, and it has become quite generally recognized that oil can never become a substitute for coal in power plants, although it undoubtedly will continue to be used extensively for marine work. The oil shortage and the high prices emphasized the fact that our oil supply is limited; in fact, oil production in this country is not sufficient by approximately four hundred thousand barrels daily for our immediate needs. Furthermore, it has been estimated that the oil reserves of this country are capable of supplying our whole power needs for only about nine years even if the best steam practice as used in the largest central stations is followed. Even when using oil under boilers to the extent of causing a critical fuel-oil shortage at the present high rate of production, it has been found that it represents only about one per cent of the coal consumption for power purposes. These figures clearly indicate that oil for fuel under stationary boilers can only be a mere incident in our fuel supply.

The tragedy of our vast national gas resources is well known; they are now depleted to such an extent that they can never be a potential factor in our fuel supply. Estimates place the limits of the natural-gas supply within one or two generations at the most, provided this class of fuel is used only for purposes for which gas as a fuel is essential. In this direction we cannot look for any relief to arrest the ever-increasing demand for coal. In fact, the reverse is true; many industries in the gas regions have been forced to go over to coal burning, increasing the coal burden.

During recent years there has been considerable movement toward the recovery of the vast culm banks at the mines, and in the anthracite regions the recovery of river coal; that is, coal washed down from the mines into the rivers and their tributaries. However, the latter supply has never exceeded about two million tons

per year. Much has been said about the culm banks, but these are fast disappearing. In a report made by the Federal Fuel Administration during the war it was estimated that there remained about forty million tons in these banks, and that probably ten years would see the recovery of most of this; therefore no permanent relief to the demand upon our mines can be looked for in this direction.

The foregoing clearly indicates that the demand upon our coal resources will continue to increase, and since the future will find more and more of our tasks performed by power and less by manual effort, the demand for power will continue to grow at an ever-increasing rate. Also the future will probably see an increased demand upon our coal resources to supply the needs of foreign countries. All of which emphasizes the necessity of eliminating every waste in our methods of fuel utilization.

## The Maintenance Engineer

YEARS ago, before T. R. told Wilhelm that he had the the finest army in the world and Bill believed him, when that pet manufacturing plant of yours was but a mere infant, there was a man on the payroll whom everybody knew as "Jack" or "Bill" or "Bob," who had no regular job, but was as versatile as the country politician, always ready to take a hand in a poker game or lead in prayer.

Gradually, as the plant grew bigger and the new people couldn't remember him by name, he was referred to as the "trouble man," and that stuck—for a while—until the "repair man" seemed a less opprobrious epithet.

Then came—war; old plants were speeded up, developing unsuspected weak spots; new plants were built, hastily equipped and thrown into high gear before the bearings were limbered up; everything going with the throttle pulled wide open and an Ethiopian perched on the safety valve.

And did Jack make good? He did. Every Jack and Bill and Bob was on the job seemingly twenty-four hours a day, seven days in the week, keeping things going from the coal pile to shipping room not only by quick repairs when and as needed, but by anticipating trouble before trouble came; guarding against it by watchfulness and intuition combined with up-to-date scientific methods.

The "maintenance department" came into its own, occupying its distinct and definite place in the organization chart, demanding recognition as a logical and important unit in the big economic structure which under efficiently balanced conditions meant output, first, last and all the time.

Not only in manufacturing plants, but in every branch of commercially productive activity, the maintenance department was recognized as functioning hand in hand with the more evident and perhaps more spectacular organization features. In one army post alone, in 1918, the maintenance officer had on his payroll more than three hundred men, including carpenters, electricians, painters, plumbers, laborers, etc., and the "output" included everything from a new door knob to the rebuilding of a steamship pier.

New conditions, new methods, new recognitions, are the order of the day; the maintenance engineer has arrived. Perhaps you may know him as the superintendent of power, or assistent chief engineer, or by some other name—it doesn't matter; the maintenance organization is an entity, functioning independently of, but correlating with, the other plant departments and in a series of articles beginning in this issue Mr. Collins tells *Power* readers what *has* been done in some plants along these lines, as a suggestion of what *may* or perhaps *ought* to be done in others, with particular reference to keeping intelligent records.

## Lubrication Specifications

IN THE correspondence columns appears a communication from the engineer of a mill in India, calling attention to a problem that confronts many engineers whose plants are situated in even more advantageous localities. The study of lubricants and their qualities is in itself a distinct branch of mechanical engineering. The engineer in charge of a power plant cannot give the subject of lubrication the proper amount of study; if he did, he would not have time to cover the hundred other duties within his sphere. Largely because of his training, he usually is swayed in the choice of lubricating oil by color, viscosity, oil base and other popular conceptions of what a suitable oil should be. For this reason the selection is largely a hit-or-miss affair. That more serious plant failures are not recorded is due solely to the fact that any oil will lubricate in some fashion.

Many engineers recognize their inability to correctly determine the proper oil to use. Recourse is then had to the lubrication salesman. Handling oils every day, visiting hundreds of plants, it is but natural that he is expected to offer sound advice. Unfortunately, it is impossible to judge the probable action of a lubricant in one plant by its behavoir in another installation unless every individual condition is studied.

In Mr. Talaty's letter may be found a suggestion to the oil-marketing companies. The oil salesman should be an engineer with the ability to determine the proper oil after a study of plant conditions. With such lubrication doctors comprising its sales force, no concern need worry over the fact that some other firm is offering a cheaper oil. In far off corners of the world nothing will bring quicker recognition of the excellence of American lubricating oil than a satisfactory diagnosis and proper prescription by a lubrication engineer. The age of clever sales talk is gradually being replaced by engineering service.

## For Secretaries Only

THERE are secretaries and secretaries. Some are making good on their jobs and others would qualify better as obituary writers for an annual magazine. This veiled compliment is directed at those members of engineering associations whose duty is, first, to record their organization's activities, and second, to announce and report them to the public and the press. With the performance of the first of these tasks *Power* is not directly concerned, but blundering in execution of the second is one of the things that turns the editorial hair gray. It is bad enough for a busy man, tied up, perhaps, for a week or ten days in advance to receive a cordial invitation on the twenty-first to attend an "interesting and instructive" meeting on the twenty-second, but when such a notice comes to a magazine with the ingenuous request that "it be given space in an early issue of your publication" it is time for somebody to take something to keep him awake. Secretaries, wake up! *Power* comes out on Tuesdays; get your announcements to us at least a week before the Tuesday on which they should appear.

# CORRESPONDENCE

## Standard Unit of Refrigeration

The article by F. E. Matthews in the issue of Feb. 1 on the standard unit of refrigeration is interesting and instructive. The refrigerating profession is greatly indebted to those who have been willing to put time and interest into the work of providing us with an acceptable basis for the estimation of the capacity of refrigerating machines. There are, however, in the article several points that are not very clear and these I believe ought to be discussed.

We know that the capacity of an ammonia compressor (for example) is affected by the condition (quality) of the suction gas, the temperature of the liquid at the expansion valve, the suction and the discharge pressures, the clearance, the proportions of the cylinder, the valve and piston leakage, and the wiredrawing through the valves and the ports. In consequence the capacity of a machine cannot be taken from theoretical sets of curves showing the precentage capacity at various operating conditions as compared with the standard pressures corresponding to saturated temperatures of 5 and 86 deg. F. respectively. Such curves can only be worked out for various designs and used with a correction factor found by experience "in the field."

In the case of the boiler test the conditions are different. We can weigh the boiler feed and take the boiler feed temperature, the boiler pressure and determine the quality of the steam leaving the boiler nozzle. The boiler rating may be obtained accurately from these simple readings, but the rating of a refrigerating machine would be problematical and unsatisfactory if there was no determination of the actual amount of the ammonia condensed in the condenser. It seems to the writer that the committee has only defined the ton of refrigeration and stated the pressures to be used for standard conditions, from which the manufacturer has to figure his own piston displacements and guarantee his own tonnage. It also appears that it would have been far better for the committee to have defined the condition that an "ammonia compressor will have the capacity of one ton of refrigeration when operating with dry, saturated ammonia at the suction bends, with suction and discharge pressures corresponding to the saturated temperatures of 5 and 86 deg. F. and when pumping 0.4216 lb. of ammonia per minute." Of course the ammonia would have to be weighed or otherwise measured. The pressures would be taken in the suction and the discharge bends.

The last paragraph in Mr. Matthews' article is not clear. It is true that the new basis of operation of 5 deg. suction and 86 deg. F. discharge temperatures is not much different from the old basis of 0 and 86 deg. as regards the ammonia required per ton of refrigeration per minute or per hour. But on account of the decreased specific volume of ammonia at the new rating we are increasing the capacity rating of all existing machines some 11 per cent instead of 1.3 per cent, as stated. Mr. Matthews did not mention the little matter of the specific volume.

H. J. MACINTIRE.

Urbana, Ill.

## Proper Lubrication for Oil Engines

One of the most frequent causes of trouble with internal-combustion engines is the lubricating oil. The engineer, unless possessed of a larger experience, must depend upon the recommendations of the engine builder and oil refiner in his choice of a suitable lubricant. The engine builder in many cases is not familiar with local conditions nor with the characteristics of the oils obtainable in out-of-the-way places in the world.

In the second place, the recommendations of the oil refinery or marketing concern cannot be followed with any degree of safety. Many representatives of these oil companies, not having the essential experience, advocate one kind of oil for all conditions of service in oil engines. The writer has had some very unfortunate experiences due to following the ideas of oil salesmen who were lacking in knowledge concerning these oils. In one case the frictional load ran up 10 per cent as a result of using an unsuitable oil.

We use one oil for the working cylinder, air compressor and main bearings. After using a number of such oils, we analyzed those purchased and kept a record of the results, which are shown in the table.

| Lubricating oil | A | B | C | D |
|---|---|---|---|---|
| Flash point, open cup, F. | 405 | 410 | 535 | 365 |
| Flash point, closed cup | ... | 335 | 510 | ... |
| Fire test | 450 | 480 | 610 | 405 |
| Specific gravity | .909 | .871 | .877 | 933 |
| Viscosity, 212 deg. | ... | 47 | 125 | ... |
| Viscosity, 140 deg. | 151 | ... | 152 | ... |

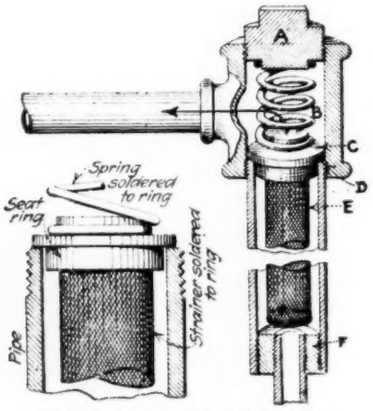
Each of these oils was sold as being suited for the service. Oil marked *A* gave satisfactory results; *B* was not suitable, giving considerable trouble in the air compressor; *C* caused the frictional load to rise perceptibly; *D* was good, the results being slightly less satisfactory than the *A* oil. These results are mentioned to show that the engineer must not depend on the representation of an oil salesman unless he knows that the latter understands the oils he is selling. Much damage has been caused by the employment of oil of poor quality in internal-combustion engines.

P. P. TALATY.

Ahmedabad, India.

## Home-Made Safety Strainer

I have had considerable trouble with oil circulation used on reduction gears of the high-speed type. These gears are lubricated by a force pump which delivers oil to them in a spray. Many strainers as built are not suitable for this purpose, as they are too small and a source of danger, having but from 1 to 1½ sq.in.




HOME-MADE OIL STRAINER

of straining surface. It is almost impossible to clean them properly.

In order to eliminate the trouble I have been having with the manufactured strainer, I made one out of a piece of 1½-in. brass pipe and a 1½-in. brass tee (see illustration). It is easy to clean, and in case it does get stopped up, the oil pressure will compress the spring, which is loaded to 3 lb., and will permit of the passage of oil, thus saving the pump, and also continue to supply oil to the machine.

Referring to the illustration, *A* is the spring compression plug which, when removed, permits of taking out the strainer for cleaning, etc., *B* is a compression spring that holds the strainer collar *C* on its seat *D*. This spring also allows the strainer to lift in case it gets stopped up; then the oil can escape around the collar *C*. The strainer *E* is a fine gage brass wire and contains about 22 sq.in. of surface. The bottom of the brass pipe is closed with a plug *F* and is the oil inlet. Of course the bottom of the strainer is closed, so that the flow of oil is from the inlet pipe through the mesh of the screen to the inside and out through the center of the collar *C*.

LEWIS T. O'DONNELL.

Cos Cob, Conn.

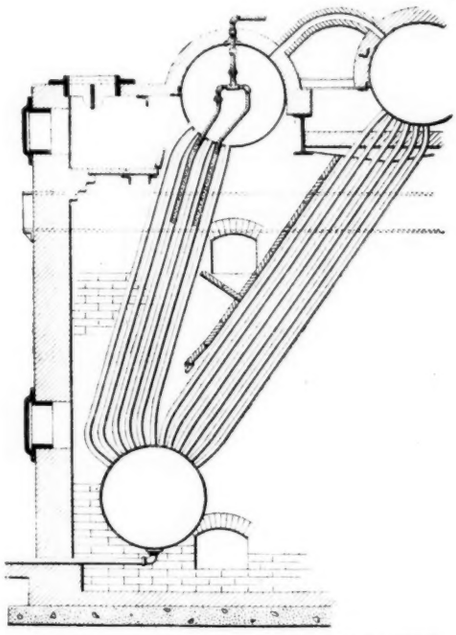
## Shutdown Caused by a Clogged Feed-Water Line

I once encountered an interesting case of trouble caused by the feed-water line inside the boiler becoming plugged with sediment. The plant in question contained two Stirling water-tube boilers. As one boiler was sufficient to carry the load they were changed over every three weeks, one being shut down for cleaning or any necessary repairs while the other was in operation. One day the shift engineer complained that he was having trouble, as the feed pump refused to work properly; the water was low in the boiler and he was unable to speed up the pump sufficiently to hold the water at the proper level.

Although the throttle valve was wide open the pump pistons moved very slowly and appeared to be pumping against a terrific pressure. The slow piston speed and the escape of steam around the rods and valve stems indicated a closed exhaust or discharge valve. However, both of these were tried and found to be open. As the pump had been thoroughly overhauled a few days before it was known to be in good condition. I eventually came to the conclusion that the feed line to this boiler had become clogged, as when the feed-line valve to the other boiler was opened the pump raced, thus indicating that the feed line to this boiler was open.

Meantime a fire had been started under No. 2 boiler, and as soon as it was on the line and the pump working properly No. 1 was cut out of service and an investigation made to ascertain the cause of trouble. The bonnets were removed from every valve on the feed line to this boiler, including the check valve, but were found to be all right and the feed line was found clean up to the point where it entered the boiler. The trouble was finally located when the boiler was opened up for cleaning and inspection. In the accompanying sketch the method of introducing feed water to this boiler is shown.

The tubes in which the feed water discharged had become clogged with scale and sediment contained in the feed water; this caused overpressure on the feed line and pump. I was interested to note that the feed line outside the boiler was practically free of scale,



PIPING OF FEED-WATER DISCHARGE

while that part inside the boiler was almost stopped up, caused no doubt by the difference in temperature of the feed water inside and outside the boiler.

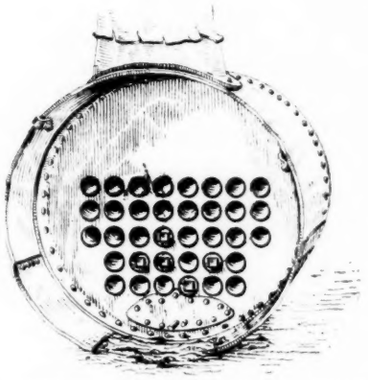
The main idea in connecting a feed line as illustrated was to keep the mud and sediment out of the upper rear drum and cause it to be deposited in the lower mud drum. This has its disadvantages, as already described. That part of the feed line inside the boiler should be inspected and cleaned at regular intervals; otherwise it is liable to become clogged with scale; especially is this true where the feed water contains a considerable amount of scale-forming ingredients in solution.

Los Angeles, Cal. ROLAND L. TULLIS.

## Why Exempt Oil Country Boilers?

Recent comments on the adoption of the A. S. M. E. Boiler Code in the oil fields recalls numerous interesting facts that are not out of the ordinary in the oil districts. The illustration provides ample argument for state regulation of such boilers. In this boiler there were five tubes plugged, and at some previous time a patch had been riveted to the tube sheet, below the lowest row of tubes. This patch had corroded until it leaked, so the pumper drove two wooden plugs into the holes, as shown.

On another boiler I noticed a globe valve piped between the safety valve and the boiler. As it looked as if it were closed, I climbed up and confirmed my suspicions. Upon calling this matter to the attention of the pumper, he said he kept it closed because the safety valve leaked and that there was no danger, as he had a pressure regulator on the gas burner (this boiler was using natural gas fuel) and he considered a regulator safer than a safety valve anyhow. As his steam gage registered about 95 lb. and I did not know how many wooden plugs the boiler contained, the outdoor air looked healthier to me.



SKETCH OF BOILER, MADE FROM A PHOTOGRAPH

It is true that most of these boilers are located where an explosion does little property damage, but wherever there is a boiler in operation there is at least one pumper, and is not his life as well worth protecting as the average factory employee's? Why guard a gear and leave steam boilers for any man to toy with?

It is worth while to bear in mind that a few boilers may be found in the villages. Wherever there is a prospect for a good well, someone will drill. Only a couple of months ago I read of a man drilling a well on a narrow strip of land between his residence and a church, in the district already mentioned.

Another dangerous element, not often considered, is the introduction of these boilers into small local enterprises, there being many of these, such as cheese factories, sawmills, etc. If a man in the oil fields starts manufacturing on a small scale and finds himself in need of steam, he purchases the first or the cheapest second-hand boiler he can find, provided it holds together while moving.

I remember, when a boy, of a small sawmill employing about six men, operating an old boiler that used to leak so badly that the wood fire would be smothered. Then they would send for a local boiler repair man to patch it up and try it again.

If the highest estimated differential cost of building A. S. M. E. and the old type boilers was reduced to the cost per foot of drilling wells over a period of time covering the average life of a boiler, the figure would be so small it would make the strongest backers of the old type look foolish. L. B. CASE.

Hudson Falls, N. Y.

## Fuel Conservation

Reading the letter of C. J. Miller, page 191 of the Feb. 1 issue of *Power*, brings to mind certain remarks that have been made by hundreds of engineers and men associated with various industries. During the world war we had a National fuel administration that was supposed to look after the distribution of fuel throughout the country and to see that it was used advantageously. The life of this organization was short, but in that time it did more to build up the efficiency of our power plants than any other agency ever brought into the field.

Strong opposition was met in some quarters against the enforced economy that was brought about by this action, but such reports as I have received through constant traveling among and visiting of industrial power plants show that the expenditures made were paid for many times over by reduced cost of operation.

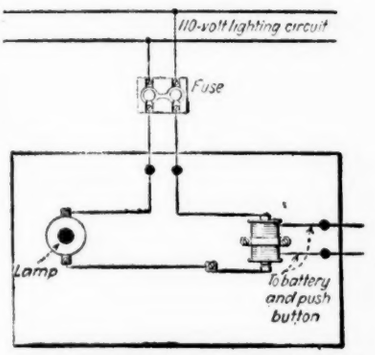
Under present conditions national apportioning of fuel is uncalled for, but a re-establishment of the fuel administration would increase the manufacturer's profit by reducing expense, it would elevate the progressive engineer by increasing his opportunities for increasing efficiency, the overloading and wear and tear on our railroads would be reduced and our natural resources would be conserved for future generations. They will never be able to recover what is being squandered in 90 per cent of the power plants of this country today. Such conditions as Mr. Miller mentions are far more frequent than most of us realize.

Why cannot this or a similar board be formed for this purpose? Everybody outside of the coal barons would benefit by it. H. K. WILSON.

New Bedford, Mass.

## Signaling System in a Noisy Plant

Under conditions where telephones and gongs were rendered useless by the excess of noise, it became necessary to provide a signaling system to replace these. Sirens were proposed but not adopted, as it was thought that something "homemade" might be installed to answer the purpose. It was finally decided to try a visible signal instead of an audible one, and the arrangement shown in the sketch was chosen. From the electromagnet of an old bell and its armature a relay was made which closed the circuit of a lamp. The relay and lamp were mounted on a slate slab 12 x 8 in., in a conspicuous position.




CONNECTIONS FOR LAMP SIGNAL USING BELL MAGNET AS A RELAY

This worked satisfactorily, and the flashing of the lamp attracted immediate attention; so a six push-button attachment was installed in the engineer's office and a cable run to the terminal board, these signals being installed at six different points about the plant. Since that time no complaints have been received.

Boston, Mass. E. S. BAXTER.

## Superpower Steam Pressures

In the Feb. 1 issue John A. Stevens presents some remarks on the problem of "Superpower Station Steam Pressure," and invites "copious criticism" of his article. The following contribution has some bearing on the question. It is intended, mainly, to draw attention to the erroneous use of the term "Rankine cycle efficiency" which Mr. Stevens makes. He gives some curves in support of previously made considerations on the best pressure and superheat to be carried in a superpower station, which curves are supposed to show the variation of the Rankine cycle efficiency with pressure and superheat. In reality they represent the theoretical thermal efficiency of the turbine (or engine); that is, the ratio of the heat that it would be possible to utilize in a perfect machine to the heat that would have to be expended in a perfect boiler in evaporating the steam.

Thus, for 350 lb. gage saturated steam, the total heat content of the steam at the turbine throttle is 1,207 B.t.u. According to steam charts, through adiabatic expansion to 29 in. vacuum 403 B.t.u. would become available for work, and since the heat of the liquid at 1 in. absolute pressure is 47 B.t.u., the theoretical thermal efficiency is equal to 403 divided by 1,207 minus 47 or equal to 34.7 per cent. This checks up with Mr. Stevens' curve, Fig. 2. Likewise, for 350 lb. gage and 265 deg. superheat, the total heat content of the steam is 1,358 B.t.u., through adiabatic expansion to 29 in. vacuum 473 B.t.u. are available, the heat of the liquid is again 47 B.t.u., therefore, thermal efficiency equal 473 divided by 1,358 minus 47, or 36.1 per cent. This checks up with curve in Fig. 3.

The term "Rankine cycle efficiency" is used as a standard of reference by which the performance of a steam engine or turbine is measured. It compares the heat actually utilized, or equivalent to the shaft b.hp., to the heat available in perfect, adiabatic expansion. Mr. Stevens uses it in its proper sense when he refers later on in his article to the Rankine cycle efficiency of the turbine as being 76 per cent, although he introduces some element of comparison by stating that this is obtained with a power factor of 0.8. The power factor of the electrical circuit has, of course, nothing to do with the Rankine cycle efficiency of the turbine. The intention may have been to convey that the electrical losses of the generator were included in this efficiency of 76 per cent, in which case the figure given is the over-all efficiency of the turbo-generator and the Rankine cycle efficiency of the turbine is 0.76 divided by 0.95, or 80 per cent, if 95 per cent is taken as the generator efficiency. This, although high, is an attainable value in large turbo-generators.

To return to Mr. Stevens' curves of theoretical thermal efficiency, it is perhaps questionable whether they are really the true criterion of what pressure and superheat may be carried to greatest advantage. Better, probably, would be curves of the actual thermal efficiency of boiler and turbine giving the work actually obtained by the heat actually expended. These would throw a light on the question whether boiler and turbine do not suffer in their efficiency after reaching a certain limit for pressure and superheat. The best criterion, undoubtedly, of economical operation would be the cost of a brake horsepower at the turbine shaft or of a kilowatt-hour at the busbars for varying conditions of pressure and superheat. This, to be complete, would have to bring into account operating cost as well as capital charges, depreciation and maintenance.

Why don't some of our large public-service stations compare notes on this subject in public?

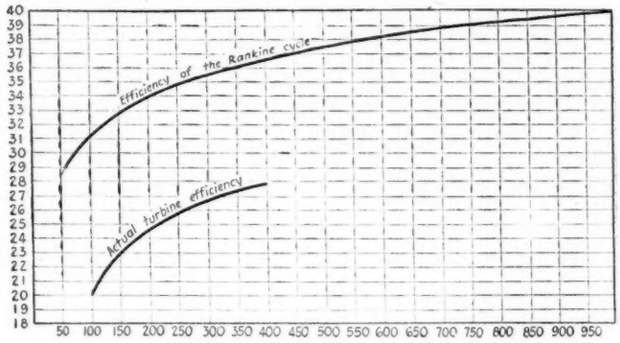
Easton, Pa. P. HOFFMAN.

---

In *Power* for Feb. 1 Mr. Stevens presents certain figures as to why he thinks 350 lb. steam pressure and a superheat of 200 deg. F. to be best choice at this time.

The accompanying chart shows the efficiency of the Rankine cycle with various initial pressures at a constant initial temperature of 700 deg. F., which is the same as shown in Fig. 3 of Mr. Stevens' letter. Under ordinary operating conditions, however, the curve for the actual turbine will be steeper than that shown for the Rankine cycle, and if we assume 76 per cent efficiency referred to the Rankine cycle at 350 lb. gage, it will probably drop off to 66 per cent efficiency at 100 lb.

This means that under actual operating conditions there is more to be gained by going to a higher steam




EFFICIENCY OF RANKINE CYCLE WITH VARIOUS INITIAL PRESSURES AT A CONSTANT INITIAL TEMPERATURE OF 700 DEGREES F

pressure than is shown by considering the Rankine cycle itself. We know that 200 lb. pressure is perfectly feasible and standard, and we are therefore interested in seeing how much will be saved per year by going to 350 lb., over what it would cost to operate at 200 lb. By referring to the curves in Fig. 1, it will be seen that we will gain 2.4 per cent by increasing the pressure from 200 to 350 lb. Assuming a 60,000-kw. unit operating at 90 per cent load factor throughout the year, we would have an output of 475 million kilowatt-hours, and on the basis of 76 per cent efficiency, this would be equivalent to the use of 309,000 tons of coal per year. On the basis of saving 2.4 per cent by going to the higher pressure, and assuming coal at $5 a ton, we would save $37,000 a year.

It is doubtful if a large plant can secure enough water near enough the coal fields to obtain coal at less than $5 a ton, so this should be a conservative figure.

Assuming a 10 per cent carrying charge, it will, therefore, be seen that if the increased pressure can be obtained for less than $370,000, it is worth while going to the higher pressure. There are a few plants that have been operating at these higher pressures for a sufficient length of time to show that there are no insurmountable mechanical difficulties likely to be encountered. I agree with Mr. Stevens that we are not warranted at the present state of the art in considering a higher pressure than 350 pounds. J. B. CRANE.

Pittsburgh, Pa.

# INQUIRIES OF GENERAL INTEREST

**Use of Ammonia Fore Cooler.**—Does it pay to install a fore cooler for the liquid ammonia before it reaches the expansion valve? G. T.

Since the ammonia in boiling in the coils must be cooled before any refrigerating effect is secured it is advisable to install a cooler whereby the ammonia gas passing from the coils to the compressor chills the liquid ammonia.

---

**Coefficient of Expansion of Firebrick.**—What is the coefficient of expansion of firebrick? F. E. C.

Experiments have shown that the coefficient of expansion of firebrick decreases with temperature rise, but an average coefficient of linear expansion within the range of temperatures ordinarily attained in boiler furnaces would be about 0.0,000,027 per degree F.

---

**Detecting Fractured Staybolt.**—What is the best method of determining whether staybolts in the side sheets of a locomotive-type boiler are defective? L. V.

When such staybolts become fractured the rupture generally occurs near the outside shell, and by drilling a small hole in the staybolt extending from its outside end to a point that is about ¾ in. beyond the inside surface of the outer sheet a fracture will be exposed by the discharge of water and steam.

---

**General Tests of Hardness and Acidity of Feed Water.**—What simple tests can be made to determine the hardness and the acidity of boiler-feed water? H. S. D.

Hardness is shown by adding to a sample of the water a few drops of a solution of castile soap in alcohol. If hard the water will be made a milky white, and if soft the water will remain clear. An acid in the water will turn blue litmus paper red. Water which will turn blue litmus paper red before the water is boiled but not after boiling contains carbonic acid.

---

**Advantage of Keeping Water in Ashpit.**—What is the advantage of keeping a boiler ashpit covered with water? M. B.

Water in an ashpit aids in preventing the grate bars from warping, as the pit is kept cool by the quenching of the coal and hot ashes which drop through, and the vapor seems to be an aid to combustion by keeping the fire cleaner on the under side and appears to hasten the kindling of fresh coal laid on the fire. There also is an advantage of having less dust arise when drawing the ashes than by only cooling them with water just prior to cleaning out the ashpit.

---

**Allowances for Shrinkage of Castings.**—What allowance for shrinkage should be made in patterns for casting? H. C. S.

The amount of shrinkage varies in different metals, in different-sized castings of the same metal and also in different dimensions of the same casting. For example, a cylinder casting will have a greater coefficient of shrinkage in length than in diameter, probably from the resistance of the central core. The usual shrinkage allowances average about as follows: Cast iron and heavy brass, ⅛ in. per foot; steel and thin brass, 3/16 in. per foot; and aluminum, lead and zinc, 3/32 in. per foot.

**Maximum Efficiency of Diesel Engine.**—Is there a limit to the efficiency obtainable from a Diesel engine? B. W.

The maximum possible thermal efficiency when operating between the usual temperature limits is 59 per cent, this being the so-called "air cycle" efficiency. With oil as fuel the maximum indicated efficiency is around 49 per cent.

---

**High Tension-Grounds for Icicles.**—Could a short-circuit result from icicles forming from the eaves of a roof to one or more conductors of a 25,000-volt three-phase line with grounded neutral? E. A. T.

Icicles would not cause a short-circuit in such a case, as pure water and the ice formed from pure water are very poor conductors. Probably there would be some leakage of current from the conductor, but if this reached any appreciable figure, it would heat the icicle and melt it. Outdoor high-tension apparatus and line insulators are frequently covered with sleet and ice without disturbing the operation of the lines.

---

**Dimmers for Incandescent Lamps.**—Why will a dimmer designed for carbon-filament lamps operate badly with tungsten lamps, even though the power supplied to the lamps be the same in both cases? V. K. S.

A dimmer cannot operate equally well on carbon and tungsten lamps, because the resistance of the former decreases and that of the latter increases as the temperature of the filament increases. Therefore when the lamp is dimmed by absorbing part of the line voltage in the dimmer the resistance of the tungsten lamp decreases, and more resistance must be supplied by the dimmer; whereas, the resistance of the carbon lamp increases, so that less resistance is needed in the dimmer. Therefore a larger dimmer is needed for metal-filament lamps than for carbon lamps.

---

**Isothermal and Adiabatic Expansion**—What is meant by the terms isothermal expansion and adiabatic expansion? E. P.

When a gas expands at a constant temperature it is said to expand isothermally. In order that the temperature will remain constant it is necessary for heat to be supplied from outside to compensate for the heat that is converted into work. Isothermal expansion may be approximated in a steam engine by means of a steam jacket around the working cylinder.

A gas expanding in a non-conducting cylinder would be said to expand adiabatically (that is, "no heat passing through") and its temperature would fall during the expansion, since there would be no heat supplied to take the place of heat that was converted into work. True adiabatic expansion is probably never realized in practice on account of the difficulty of securing the variations of temperatures that should exist at the different stages of the expansion; but adiabatic expansion is closely approximated when the expansion occurs suddenly, as in a steam turbine, for there is then little time for the conduction of heat.

---

[Correspondents sending us inquiries should sign their communications with full names and post office addresses.—Editor.]

# Pulverized Coal for Power Plants*

By FREDERICK A. SCHEFFLER

THE limitations in coal-burning methods in the present state of the art are presumably well known to engineers. It is poor engineering, to say the least, to continue to place ourselves in a position where it is necessary to demand a particular kind of coal suitable only to our immediate furnace and grate conditions. Why not go a big step further and fix those conditions so as to be independent of the supply of coal from any particular mine and burn any and all of the various grades, sizes, high or low ash or sulphur content with equal success? Most emphatically we can, and the answer to the question is, *pulverize the coal.*

But this pulverization must be of a sufficient fineness actually to produce what we may term "mechanical gas" when properly mixed with air. It will not do merely to granulate the coal. It must be an impalpable powder. Everybody knows what talcum face powder is. That is the nearest example of what powdered or pulverized coal must be to give the results we seek and can and do obtain.

Z—Zone of combustion controlled so as to prevent unconsumed gases going out of the chimney.

E—Efficiency easily maintained at the highest point.

D—Dust and smoke reduced to a minimum.

C—Coal can be burned in pulverized form whatever the percentage in ash.

O—On whatever load, the operating conditions are always ideal.

A—All the combustible in the coal is consumed, none is lost with the ash.

L—Labor of firing and ash removal is considerably reduced.

Four years hence the demand for coal for power purposes will be practically double that required at the present time, if the rate of demand in the past is any indication of future growth. It is impossible, in the Eastern States at least, to rely on supplying much of this increased demand from hydro-electric or other water-power developments.

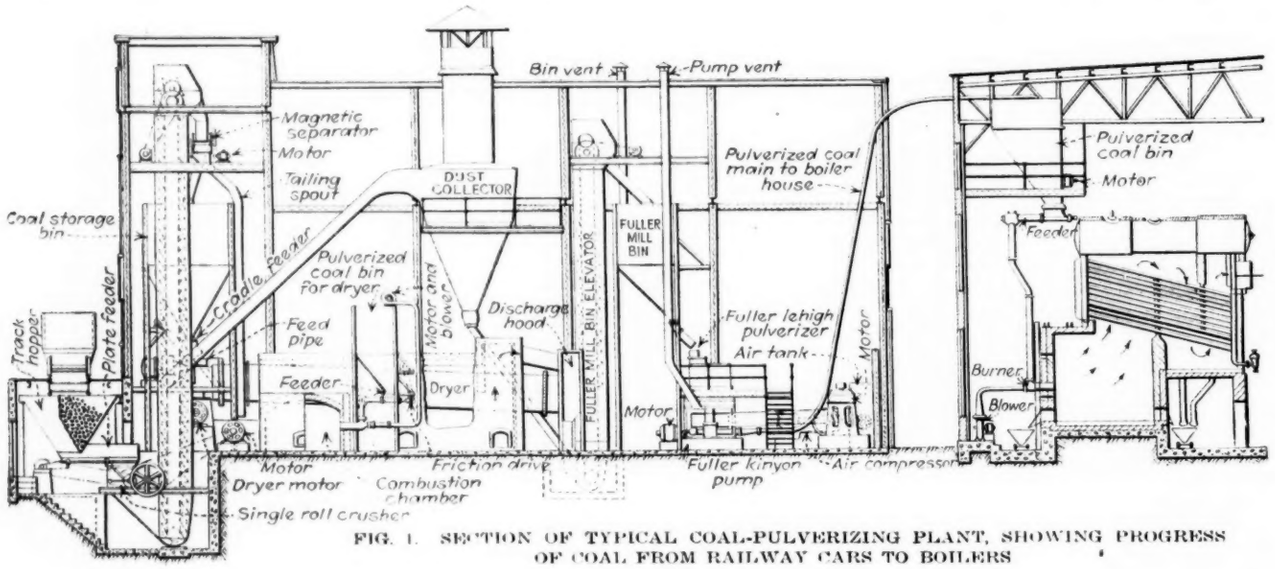



FIG. 1. SECTION OF TYPICAL COAL-PULVERIZING PLANT, SHOWING PROGRESS OF COAL FROM RAILWAY CARS TO BOILERS

We must get this coal so fine that every bit of carbon in it will be burned in suspension before the gases are permitted to come in contact with the boiler-heating surface. We must not throw out in the ash dump from 10 to 40 per cent of the carbon (B.t.u.) originally in the coal. We must utilize every bit of these valuable heat units to make steam and increase boiler and furnace efficiency to the utmost, even if it means an addition of only a half of one per cent. But in 75 per cent of our boiler plants 3 to 4 per cent can be added to the boiler efficiency if the carbon in the ash is eliminated.

This is only one of the numerous advantages to be obtained with pulverized coal which I will briefly summarize, as follows:

P—Perfect combustion.

U—Utilization of low-quality combustibles.

L—Labor cost for operation and repairs reduced.

V—Variation in loads easily controlled.

E—Elimination of stand-by losses.

R—Reduction of excess air to a minimum.

!—Increase in the efficiency and reduction of coal used.

The statement has been made on very good authority that only 15 per cent of the total power available in the proposed superpower Eastern District development is supplied by hydro-electric power, and it is apparent that this percentage will fall to only 7½ four years hence. As the remainder of this power must be supplied by coal, a simple calculation will show what large increases will be made in the coal requirements by 1925-26.

It is all the more necessary, therefore, that we should, as engineers, use as little coal as possible in our power developments, and where low grades are available (which is general in the United States) use them by pulverizing and conserve the best grades of coal for gas, coke and other necessities.

All the details have been worked out to suit any kind of fuel and all possible combinations of power requirements, but if a plant requires less than 60 to 75 tons per day (24 hours), then the chances are that that plant will be unable to use pulverized fuel unless it is the nucleus of a larger plant, because the first cost will be quite prohibitive.

The first successful commercial pulverized-coal installation of 20,000 sq.ft. was made four years ago. The great war intervened and the 2½ years which ensued saw only

*Abstract of paper presented before the American Society of Heating and Ventilating Engineers at the Annual Meeting, Philadelphia, January, 1921.

about 200,000 sq.ft in operation, but the succeeding 1½ years (to January, 1921) added about 700,000 sq.ft. of heating surface, a growth in 1½ years almost as phenomenal as was the growth of the Curtis steam turbine in its early days.

Brief data concerning installations made in the last four years will be of interest:

### Some Recent Pulverized-Coal Installations

a. The first, already referred to, has been in continuous operation, and the brickwork on side and other walls of the furnace is still in excellent condition. This plant has burned in pulverized form, Texas lignites, Kansas bituminous and other coals. The flexibility of furnace operation is shown by the fact that for one year fuel oil was used because of its cheapness, and the plant is now back on pulverized coal because it is cheaper than fuel oil.

b. A sugar refinery changed to pulverized coal from fuel oil nearly two years ago on its 13 boilers (24-hour service daily, Sundays and holidays) and is saving about $100,000 a year. Additional boilers are being installed, which will also be fired with pulverized coal.

c. A steel company that had been using pulverized coal for fifteen years in steel-furnace work discovered that its waste-heat boilers could be direct-fired to advantage with

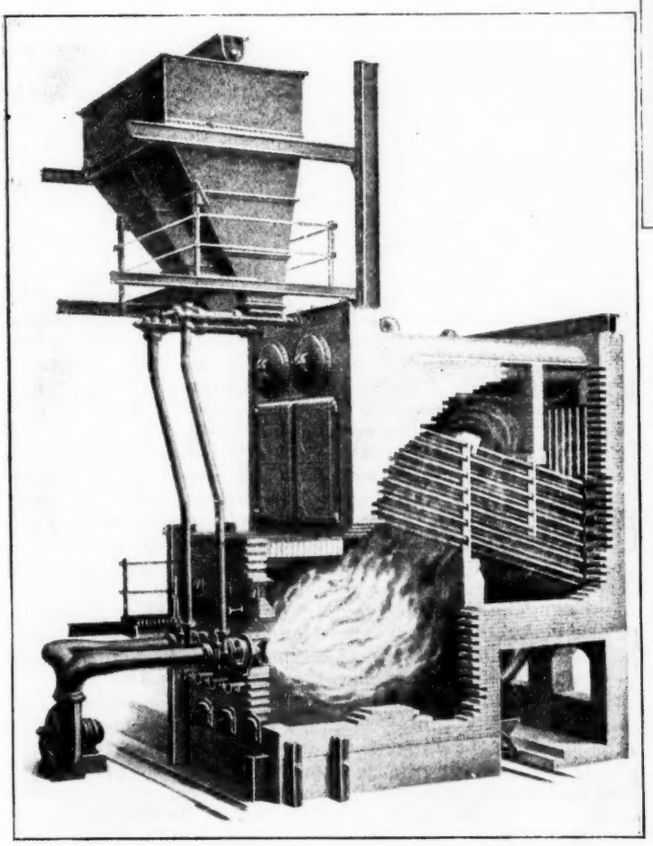


FIG. 2. TYPICAL APPLICATION OF PULVERIZED-COAL FIRING TO BABCOCK & WILCOX BOILER

pulverized coal when the source of waste heat was out of commission. The result was so satisfactory that 20,000 sq.ft. of new boiler equipment, direct-fired, was arranged for pulverized coal, and this coal is delivered in a 4-in. pipe by the Fuller-Kinyon material-distributing system 800 ft. away from the milling plant. The boiler and furnace efficiency of this plant is 83 per cent and for the month of October, 1920, the plant efficiency (including economizers) was 85 per cent. One fireman on a shift takes care of the four boilers, tends water and blows tubes, the latter every twelve hours.

d. A central station (public service) using 150 tons a day of pulverized coal under half its boilers for two years and underfeed stokers under the other half, under identical operating conditions, decided to install pulverized coal in the first unit of a new 200,000-kw. plant. This unit is of 40,000 kw. and is practically ready to go into commission.

e. A cement company has placed one of its five 4,000-sq.ft. boilers on pulverized coal, situated 1,000-ft. from the mill-

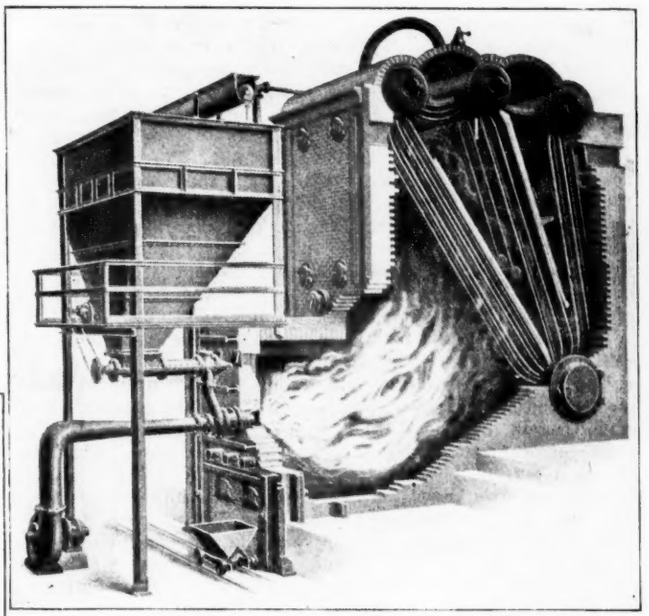


FIG. 3. TYPICAL APPLICATION OF PULVERIZED-COAL FIRING TO STIRLING BOILER

ing plant, transmitting the coal through a 3-in. pipe by the aforementioned system. These people have burned bituminous, anthracite, culm and Rhode Island coal in the same furnace most successfully, and have pulverized all these different grades of coal without making any changes in the equipment. This demonstrates the flexibility of the apparatus.

f. A copper smelter changed two of its six 4,000-sq.ft. boilers to pulverized coal. The result was that the firemen "lay down" on the hand-fired boilers and practically threw all the load on the pulverized-coal fired boilers, which raised trouble generally with the furnaces of the latter, as they were only designed for 150 per cent of rating continuously. But this illustrates how quickly the firemen grasped the "snap" offered in this new method of firing. The other four boilers have been ordered equipped for pulverized coal.

g. An anthracite mining company equipped a boiler for anthracite, culm or other unsalable coal. After operating two years, plans have been prepared for a 10,000-kw. plant to use a bank of culm (about two million tons) and other coals such as sludge, mine dirt, etc. These parties also have another 10,000-kw. plant fired by pulverized coal, and in this plant the high record (for anthracite) has been made for boilers operating continuously at 300 per cent rating and for several hours at over 400 per cent. Efficiencies of boiler and furnace at these plants of 80 per cent are not unusual.

h. The writer knows of at least eighteen tests that have been made with a variety of coals in pulverized form, and the average of these tests gives over 80 per cent boiler and furnace efficiency over periods of from 6 hours to 26 days, whereas the average of thirty selected tests published by a prominent boiler manufacturer on comparatively short periods and loads from 85 per cent to 200 per cent rating is 70.2 per cent with good coals and including hand firing, chain-grate, underfeed and other types of stokers.

# Non-Condensable Gases in Ammonia Absorption Systems*

By E. C. McKelvy and Aaron Isaacs

One of the great difficulties encountered in the operation of an ammonia absorption refrigeration machine is the formation of foul or non-condensing gases. The presence of these gases is usually indicated by the increase in the operating pressure of the ammonia plant. If a sample of liquor from the generator of such a plant be taken, it will always be colored a deep brown and will deposit a sediment upon standing, thereby showing that corrosion has accompanied the gas formation within the generator. However, the corrosion of the interior of the generator is of secondary importance. The foul gas causes the most trouble, since the plant must be purged of this gas just as often as it forms, with resulting loss of ammonia. The presence of foul gas makes it necessary to operate the plant at higher temperatures and pressures, thereby causing greater leakage, more corrosion, more danger from possible explosions, and increased wear on the plant. The non-condensing nature of the gas causes decreased efficiency of the compressor and consequently decreased efficiency of operation of the refrigeration plant as a whole.

In order to study the composition of the gases formed, samples from a number of plants were collected and analyzed. The percentage composition of the different samples varied considerably, but in every case the gas consisted of nitrogen, hydrogen and oxygen. In some cases the hydrogen content was as high as 98 per cent, while in others it was as low as 1 or 2 per cent. Where the hydrogen content was very small in amount, the nitrogen content was very large, and vice versa. The oxygen was usually only a minor constituent and was never present in any appreciable quantity unless the nitrogen content was very high. It was soon recognized that the nitrogen and hydrogen must come from different sources and could not come from the decomposition of the ammonia, even though in many cases the gases were present in approximately the proportions to form ammonia. Ammonia will not decompose into its constituents under the conditions of operation of an absorption plant. However, there was a possibility of the formation of nitrides or amines.

### Testing Sludge for Nitrides and Amines

Some of the sludge from the absorption plant at the Bureau of Standards, which was giving much trouble at that time, was tested for these by dissolving in acid, making the solution alkaline and distilling into standard acid. Under this treatment ammonia would be produced if any amines or nitrides were present. There was, however, no evidence of the presence of either of these compounds. This fact pointed strongly toward the conclusion that in those plants where nitrogen or a mixture of nitrogen and oxygen was found in the gas, these impurities were caused by air that had leaked into the system. The action of air within such a system, therefore, was one of the points that were studied. The presence of hydrogen had to be explained in another manner, and such large quantities as were found in some plants could not be accounted for on the basis of the interaction of either pure water or pure ammonia with the iron. Therefore the effect of possible impurities in ammonia on its corrosive action was studied in order to find out definitely, if possible, if these might be the cause of gas formation and, if so, to devise a means of overcoming the difficulty.

From the results cited, it is seen that if air is permitted to enter the system, as may readily happen under certain faulty conditions of operation, there will result finally an atmosphere of nitrogen containing more or less oxygen. It was also found that such impurities as carbonates, acetates and acetonitrile increase the corrosive power of aqua ammonia at ordinary operating temperatures to such an extent as to account readily for the hydrogen found in many plants.

The two impurities present in aqua ammonia that cause corrosion are acetates and carbonates. If acetonitrile is present, it is at once saponified and converted into an acetate by the heated aqua. It is contended that because of its method of manufacture ammonia made from ammonium sulphate is the only ammonia that is free from acetonitrile. No carbon dioxide is present in anhydrous ammonia. However, examination of a number of samples of aqua ammonia showed that carbon dioxide was always present, and the amount may be increased by exposure to atmosphere. In testing samples of aqua for corrosive properties, it was found that from a determination of the carbon-dioxide content the action of the aqua could be predicted. Where the content of carbonate is not over 0.003 per cent, the corrosive action is not very marked. And it was also noted that where corrosion once starts it will continue during the life of the charge.

From the foregoing evidence it is seen that one of the most important tests of aqua ammonia to be used in an absorption refrigeration machine is the determination of its carbon-dioxide content. Since a content of carbon dioxide as low as 0.003 per cent will cause gas formation, a method that will permit the use of large samples, usually 100 g., was adopted.

### Potassium-Dichromate as a Corrosion Preventive

Among the substances that have been proposed for preventing the corrosion of iron in general is potassium-dichromate solution. The authors therefore conducted experiments to determine whether a dichromate would be useful in ammonia systems. As these experiments were performed during the period of the war, dichromate was used and was found to be very satisfactory. Solutions of aqua ammonia were made up to contain the various corrosive constituents and in addition approximately 0.2 per cent by weight of commercial sodium dichromate. In all cases the amount of gas produced was very small and less than that given by the best sample of ammonia solution that had been tested without the addition of dichromate.

Much trouble had always been experienced with the operation of the 30-ton Carbondale absorption plant at the Bureau of Standards. Gas was being formed continually, and this caused large losses of ammonia in purging the system of foul gas, as well as losses due to leakage caused by the high working pressure necessary because of the presence of non-condensable gas. The ammonia charge at this plant became depleted during the winter of 1916-17, and it was found necessary to partly recharge it. Analysis was made of the ammonia solution that still remained in the machine, and it was found to contain 19 per cent of ammonia and about 0.066 per cent of carbon dioxide. In recharging this system, tap water containing about 0.0052 per cent total carbon dioxide, and anhydrous ammonia were used. After recharging the system and operating for a few months, the carbon-dioxide content had increased to 0.087 per cent and there was considerable corrosion and gas formation. The analyzed samples of liquor, when tested in the experimental bomb, were found to cause a great deal of corrosion and gas formation, but when sodium dichromate was added, gas formation was stopped.

In June, 1917, an amount of sodium dichromate equal to 0.2 per cent of the total weight of the aqua ammonia charge was added in the form of an aqueous solution to the plant. No trouble has since been experienced with the plant from gas formation. At one time when the engineer reported that considerable gas was being formed in the plant, the gas was found upon analysis to consist of 95 per cent nitrogen with a small percentage of hydrogen and a small amount of oxygen. It was soon found that this gas was caused by leaks around the piston rod of the ammonia pump. On replacing the worn-out rod, gas troubles ceased and have not been experienced since.

*Extracted from Bureau of Standards Bulletin No. 180.

---

New Zealand now has in operation 71 local electric supply plants having a total capacity of 45,805 kw. Several of these plants are being changed to the three-phase 50-cycle system, which the New Zealand Government intends to standardize. A great many new developments are being proposed, and there appears to be an opening there for American electrical machinery and supplies, provided necessary assistance can be given in financing the projects.

# Washington News

## Power Commission Issues Statement — Work Held Up at Muscle Shoals—Bureau of Mines To Analyze Coal Shipments

By Paul Wooton
Washington Correspondent

The recently promulgated regulations of the Federal Power Commission are coming in for some criticism, which is directed particularly against the accounting regulation. One of the criticisms is that these regulations embody the extreme theories of the depreciationists. The following statement, therefore, which was made in defense of the proposed regulations, by O. C. Merrill, the executive secretary of the Federal Power Commission, is of especial interest at the present time. Mr. Merrill said:

The principles which were adopted in drafting the regulations are those which have been followed for many years by the Interstate Commerce Commission in prescribing the method of accounting for depreciation of railroads and other carriers, and are practically the identical requirements of that Commission with respect to telephone companies operating under its jurisdiction. These identical principles have been applied by the Valuation Division of the Interstate Commerce Commission and adopted by the commission itself in passing upon valuations, as evidenced in its decision in the Texas Midland case. Furthermore, under the provisions of the recent amendments to the Interstate Commerce Act which require the Commission to prescribe the "classes of property for which depreciation charges may properly be included in operating expenses and the percentage of depreciation which shall be charged with respect to each of such cases of property," the commission is now conducting an investigation for the purpose of ascertaining the "classes of depreciable property (by groups if practicable), the method of ascertaining the service life and salvage value, the basis upon which depreciation charges should be accrued, the necessity for accruals, and the manner in which the percentages of depreciation applicable to the several classes of property should be determined," with the view of prescribing amended rules and regulations which will make effective the present provisions of the Interstate Commerce Act. Under the present rules the accounting for depreciation by carriers subject to the jurisdiction of the Interstate Commerce Commission is mandatory only as to certain classes of property. As to steam railroads, for example, it is limited to rolling stock, and it is the intention, so I am informed, to make the rules mandatory as to all classes of depreciable property. I am also informed that the investigation thus far made shows that a majority of the state public-service commissions have adopted the straight-line method of accruing depreciation, computing the percentages upon the original cost of the property and its estimated useful life. This is precisely the method proposed in the regulations.

Similar, if not identical, principles are followed by the Federal Trade Commission and the Bureau of Internal Revenue of the Treasury Department. The accounting classifications which I have examined show that the same is true of the States of Arizona, Idaho, Illinois, Maine, Maryland, Michigan, New Hampshire and Pennsylvania, and probably of California, Missouri and New York. This method was recognized by the United States Supreme Court in its decision in the Knoxville rate case.

After the House had voted decisively to insist upon the elimination of the appropriation for the Muscle Shoals dam, the Senate receded and allowed the Sundry Civil Bill to pass without the appropriation.

Immediately that the matter was decided, orders were sent out from the Corps of Engineers to discontinue that portion of the work which it would be safe to leave in its present state of completion. At Jackson Island the work will continue until it has reached a point where the cofferdam may be removed. In the same way a considerable saving can be effected by continuing work a few weeks longer on the south abutment.

About $1,000,000 of the existing $17,000,000 appropriation remains unexpended and unobligated. This will be sufficient to allow for the maintenance of the plant until August, 1922, which is the earliest probable time that an appropriation for continuing the work will become available.

It is admitted by all that the fight over this power project has not been ended.

An important agreement has been entered into between the United States Bureau of Mines and the Tidewater Coal Exchange, Inc., providing for co-operation in determining the quality of coal shipments.

The Bureau has agreed to direct the collecting and analyzing of samples of coal as shipped and of mine samples when necessary, using its standard methods and equipment and furnishing certified reports of each finding. The analyses will be made at the Bureau's Pittsburgh station, and it is agreed that the taking of samples must not interfere with the railroad operation.

The Exchange has agreed to make and publish classifications on the basis of the analyses furnished by the Bureau and to assign coal to pools within the limits and tolerances as finally published. The Exchange is to pay all expenses for work mutually agreed upon and is to make the necessary arrangements when coal must be sampled at the mine.

The agreement is to end June 30, 1921, unless renewed, but may be ended on 60 days' notice by either party.

The analysis and classification of coal by a co-operative scheme such as this has long been proposed by O. P. Hood, chief mechanical engineer of the Bureau of Mines. The venture is being watched with considerable interest for its possible effect on future legislation.

## President Carman Speaks at Chicago

At the close of six weeks' tour in the interests of the American Society of Mechanical Engineers, Edwin S. Carman spent the evening of March 4 with the Chicago Section. After several reels of motion pictures showing the manufacture of Byers wrought iron pipe and a short business meeting, President Carman made an eloquent plea for further support of the Federated American Engineering Societies and predicted the coming importance of the engineer in controlling industrial relations.

Mr. Carman warmly praised the new Federation as an agency that will help to retain the country's leadership among all nations, and strongly urged the Chicago engineers to get together and join the movement as a powerful local unit.

He declared that there is coming a tremendous advance in the development of mechanical appliances, which will give the engineer constantly increasing opportunities, but that in addition to this engineers will find themselves peculiarly well fitted to enter the rapidly growing field of personnel management. He described the thorough, impersonal, scientific attitude of the engineer as a quality that will make him of the utmost value not only in overcoming technical problems, but in eliminating friction between employer and employee.

## Possible Use of Substitutes for Gasoline

The development and marketing on a large scale of a satisfactory substitute for gasoline would, of course, aid materially in conserving the nation's resources of petroleum-derived motor fuel. Numerous substitutes have been proposed which the inventors and promoters claim will accomplish this desired end, but the absence of competition with the petroleum-refining industry is noteworthy. The inventors have failed chiefly because they did not understand the physical and chemical requirements of a satisfactory motor fuel, or because they did not investigate supply and cost of their raw material. There are, however, two types of substitute fuel now on the market which are of recognized importance, although they do not promise a real solution of the problem of motor-fuel resources.

The substitute material in one of these fuels is a mixture of hydrocarbons derived from the distillation of coal. These co-called coal-tar distillates, chiefly benzol and toluol, were in such great demand during the war that equipment for their production and recovery was tremendously increased. Since the end of the war these fuels have been studied with the idea of marketing them in such form as to be satisfactory motor fuel. Such marketing has already occurred, and information at hand indicates that the substitute fuels are being used with satisfaction. Some of the

factors to be considered in regard to the use of coal-tar distillates are the following: Benzol (the correct chemical name of which is benzene) is the most volatile and the most plentiful of the hydrocarbons derived from coal. Its homologue, toluol (correct chemical name, toluene) was in greater demand as a raw material for munitions, and even before the hostilities ended there was an overproduction of benzol because its production is necessarily incident to that of toluene.

Straight benzol is undesirable as a motor fuel on account of its relatively high freezing point (42 deg. F.). Toluene freezes at about 50° F., and when mixed with benzol reduces the freezing temperature of the latter to a satisfactory mark. The same reduction of freezing point may be accomplished by blending petroleum gasoline with benzol. A further advantage in blending benzol and toluol with petroleum distillates is that the resulting mixtures resemble gasoline more closely in their behavior in engine carburetors. The unblended coal-tar distillates can be used, but generally, perhaps invariably, adjustments in carburetion are necessary.—*Bureau of Mines Bulletin 191.*

The recent gasoline survey made by the Bureau of mines has revealed the fact that coal-tar distillates are being marketed in some of the larger cities—such as Chicago, Cleveland, Pittsburgh and Buffalo—mostly those having byproduct coking plants near them. However, the use of such coal products is not likely to have an important influence upon the motor-fuel situation except in regions thus favorably situated.

The combined amount of benzol and toluol produced in 1918 has been estimated at less than 4 per cent of the gasoline production. The possible maximum importance of coal as a source of motor fuel has been discussed in one of the Bureau of Mines Bulletins. It was shown that if all the bituminous coal mined in the country in the year 1916 had been run through byproduct ovens the total amount of so-called light oils would have been less than 34 per cent of the gasoline production for that year. Since that time the nation's gasoline production has practically doubled, whereas there has been an increase of only about 17 per cent in the production of bituminous coal.

A type of substitute fuel that has appeared on the market is a blend containing alcohol as one of its important ingredients. The Bureau has had little opportunity to study the marketing of this fuel, but at the time of the 1919 survey its selling was observed to be six cents above the retail price of gasoline marketed in the same city. Alcohol is undoubtedly one of the important potential motor fuels, as the raw material from which it can be made is practically unlimited. However, the indications are that before alcohol can compete successfully with petroleum gasoline the latter must reach a higher price scale than now exists and substantial modifications must be made in the design of automobile engines.—*Bureau of Mines.*

## Obituary

**Capt. David W. Payne**, inventor of the Payne automatic engine and editor of *Steam*, died recently at the age of 79 years. He was formerly an engineer officer in the United States Army and was a distinguished mechanical engineer in civil life. Captain Payne was widely known as a scholar in engineering matters and was the author of a book called "Foundry Practice." His most notable invention was an early type of high-speed shaft-governed Corliss engine. He was the son of the late Benjamin W. Payne, who founded the well-known engine-building firm of B. W. Payne and Sons. The engines built by this concern were among the first to be used for electric lighting purposes in the early days of the electrical industry.

**William D. Forbes**, well known for his work as a designer and engineer and as a manufacturer of high-grade engines and other products, died on February 17 at his home in New Orleans. He was born in Perth Amboy, N. J., but went abroad in his youth and later served in the Franco-Prussian war. Before returning to this country he served on the editorial staff of *Engineering*, of London. He was well known in the field of marine engineering and was an authority on guns. He was chiefly famous, however, for his indomitable cheerfulness, which was disclosed when he met financial reverses and became totally blind. He continued his work with the aid of his wife as secretary, and his daughter as draftsman, and designed and developed a notable automatic rifle. He learned to run a typewriter and in the last few years has contributed a number of articles to *Power* and the *American Machinist.*

## Personals

**Frank Martin**, of Jenkins Bros., and prominent in the N. A. S. E., is steadily regaining his health and will probably be able to return to his business next Fall.

**Carl C. Thomas**, who was formerly professor of mechanical engineering at Johns Hopkins University, has gone into business as a consulting engineer, with his office in Los Angeles, Cal.

**Benjamin F. Thomas**, previously mechanical engineer of the United Railways of St. Louis, has taken a position as assistant superintendent of power for the Scullin Steel Co., of St. Louis.

**Walter C. Strunk** has left his position with the mechanical research and construction division of the motive-power department of the Interborough Rapid Transit Co., New York City, to become associated with the stoker division of the Westinghouse Electric and Manufacturing Co., at Lester, Pa.

## Society Affairs

**Evansville, Ind.**, is being favorably considered for the next N. A. S. E. national convention.

**The Iowa State National Association of Stationary Engineers** is to hold its next convention in Davenport, June 22-24.

**The American Boiler Manufacturers' Association** is to hold its annual convention at Bedford Springs, Pa., June 20-22.

**Buffalo Section, A.S.M.E.**, will meet on March 15 to hear Joseph Harrington speak on "Powdered Coal vs. Stoker Firing."

**Philadelphia Section, A.S.M.E.**, will meet March 22 to hear Richard Stillane speak on the subject "How the Engineer Can Best Capitalize Himself."

**The New York State Convention** of the National Association of Stationary Engineers will be held June 9, 10 and 11 at the McAlpin Hotel, New York City.

**The Engineering Society of Akron** will meet on March 21, when C. E. Granger, of the Kelly Springfield Tire Co., will discuss "The New Viewpoint in Industrial Engineering."

**The Providence Engineering Society** will hold a joint meeting with the A.I.E.E. March 15, at which C. C. Whittaker, of the Westinghouse Company, will speak on "Electrification of Steam Railroads."

**The International Railway Fuel Association** is to hold its thirteenth annual meeting at the Hotel Sherman, Chicago, Ill., May 24-26, which practically coincides with the date of the A.S.M.E. spring meeting.

**The Detroit Engineering Society** will hold a joint meeting with the A.I.E.E. on March 18, at which B. G. Lamme, chief engineer of the Westinghouse Electric and Manufacturing Co., will speak on "The History of the Induction Motor."

**The Membership of the A.S.M.E.** research subcommittee on stresses resulting from vibration of shafting, as decided upon at the society's recent council meeting at Syracuse, is as follows: H. W. Akimoff (chairman), H. T. Smith, E. C. Newcomb, C. F. Bailey, C. P. Witherbee, B. A. Behrend, F. Hymans, H. T. Dickinson, M. W. Torbet and A. H. Beyer.

**The American Society of Mechanical Engineers** has appointed a committee comprising three past presidents, Ambrose Swasey, Charles T. Main and Ira N. Hollis, to take part in the general engineering convention to be held by the Institution of Civil Engineers in London in the summer of 1921. This action was taken in response to the institution's invitation to the four founder societies, and the A.S.M.E. has suggested that the other three societies appoint the same men with others, perhaps, as their delegation to England.

## Business Items

**The Chippewa Pump Co., Inc.**, has established its Chicago office at 201 East Ontario St.

**The Advance Machinery and Supply Co.**, Denver, Col., has secured as its new vice president and sales manager W. W. Joy, who for the last three years has been special sales promotion representative for the Fisher Governor Co.

**Dwight P. Robinson & Co., Inc.**, engineers and constructors of New York City, have recently opened a branch office at Montreal in the Dominion Express Building in charge of Alexander C. Barker, vice president of the company.

**The Bacharach Industrial Instrument Co.**, maker of gas and air meters, pressure and draft recorders, Pitot tubes, $CO_2$ indicators, manometers and engine indicators, has recently moved into larger quarters at 7,000 Bennett St., Homewood Station, Pittsburgh, Pa.

**The J. G. White Engineering Corporation**, 43 Exchange Place, New York, N. Y., is sending out a folder, entitled "Achievement," illustrating and describing power developments, hydro-electric developments, transmission systems and other engineering projects in this and in foreign countries.

**The Locomotive Superheater Co.**, having outgrown its field and having taken up the manufacturing of equipment for marine and stationary work, has changed its name to the "Superheater Company." The company recently appointed Gilbert E. Ryder, Henry B. Oatley and Charles H. True as vice-presidents.

## Trade Catalogs

**George S. Herrick**, Syracuse, N. Y., maker of the Herrick shaking grate, is distributing a 5 x 7-in. booklet entitled "A Grate Proposition," showing the construction of the grate and typical installations.

**The National Tube Co.**, Pittsburgh, Pa., has put out a new 48-page, 8½ x 11-in. bulletin describing refrigerating piping. The booklet contains rather more than the usual quantity of engineering data, going into its subject with commendable thoroughness.

**The Reading Iron Co.**, Reading, Penn., is distributing its new 8½ x 11-in. 3-page bulletin No. 2, which deals in considerable detail with the structural differences in wrought iron and steel. The booklet contains some interesting photo-micrographs and tables.

# FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

| Coal | Market Quoted | Mar. 1, 1921 | Mar. 8, 1921 |
|---|---|---|---|
| Pocahontas, | Columbus | $3.50 | $3.50 |
| Clearfield, | Boston | 2.55 | 2.15@3.00 |
| Somerset, | Boston | 3.10 | 2.50@3.75 |
| Pittsburgh, | Pittsburgh | 2.35 | 2.25@2.50 |
| Kanawha, | Columbus | 2.50 | 2.25 |
| Hocking, | Columbus | 2.25 | 2.15 |
| Pittsburgh No.8 | Cleveland | 2.35 | 2.25@2.50 |
| Franklin, Ill., | Chicago | 2.75 | 2.25@3.00 |
| Central, Ill., | Chicago | 1.85 | 1.50@2.25 |
| Ind. 4th vein, | Chicago | 2.60 | ..... |
| Standard, | St. Louis | 1.95 | 1.90@2.00 |
| West Ky., | Louisville | 2.25 | 2.35@2.50 |
| Big Seam, | Birmingham | 3.05 | 2.70@3.25 |
| S. E. Ky., | Louisville | 2.75 | 2.50@3.00 |

DIESEL FUEL OIL

**Chicago**—24@28 deg. Baumé, $1.10@$1.20 per bbl.; 32@34 deg., 3½@4½ c. per gal.

**Cincinnati**—In 8,000-gal. tank cars; 26@28 deg., 9½ c. per gal., 30@34 deg., 10c.

**Philadelphia**—26@28 deg. fuel oil, 8½c. per gal.; 30@34 deg. gas oil, 10½c.; 16@20 deg. boiler oil, 6c.

**St. Louis**—Base plus freight: group 3 24@26 deg., $1.10@$1.25 per bbl.; 26@28 deg., $1.20@$1.35; 28@30 deg., $1.30@$1.45; 30@32 deg., $1.40@$1.55; 32@34 deg., $1.50@$1.65. No market for 16@20 deg. Baumé boiler oil.

# New Construction

PROPOSED WORK

**N. H., Salem**—Arlington Mills plans to build a power house. H. K. Barrows, 6 Beacon St., Boston, Engr.

**Mass., Agawam**—The School Bldg. Comn. plans to build a 2 story, 60 x 140 ft. high school on Main St. About $250,000. W. E. Dibble, 317 Main St., Springfield, Archt.

**Mass., Boston**—The city will soon award the contract for a 2 story, 171 x 177 ft. building on Maxwell and Selden Sts., Dorchester. About $400,000. H. H. Atwood, Ashmount St., Archt.

**Mass., Boston**—The Northeast Baptist Hospital, 53 State St., is having sketches prepared for a hospital on Parker Hill, Brook line. About $400,000. W. I. Badger, Trustee.

**Mass., Worcester**—The Central Supply Co., 179 Commercial St., will soon award the contract for an 8 story, 90 x 115 ft. store and office building including a steam heating system on Foster St. About $500,000. James Rice, 306 Main St., Archt.

**R. I., Newport**—The Newport Casino Corp., representing owner, plans to build a hotel. About $1,500,000.

**Conn., New Britain**—The New Britain General Hospital, 92 Grand St., is having sketches prepared for an addition to hospital on Grand St. About $450,000. Stevens & Lee, 9 Park St., Boston, Mass., Archts.

**N. Y., Brooklyn**—The Bd. Educ., 500 Park Ave., New York City, received bids for installing heating and ventilating equipment in the additions to Pub. School 73 on the corner of McDougal St. and Rockaway Ave., from Teran, Mahaney & Munroe, Grand Central Terminal, New York City, $93,000; J. C. Williams, Inc., $94,497; Federal Heating Co., 300 Madison Ave., New York City, $96,000.

**N. Y., Cadyville**—The International Paper Co., 30 Church St., New York City, will soon receive bids for a hydro-electric plant on Saranac Rd. About $250,000. A. H. White, Archt. and Engr. Noted Dec. 14.

**N. Y., Jamaica, L. I.**—St. Marys Hospital, Shelton Ave., is having plans prepared for a 6 story, 100 x 250 ft. hospital including a steam heating system on Shelton Ave. About $1,000,000. W. J. Boegel, 162 East 37th St., New York City, Archt. and Engr.

**N. Y., Long Island City**—The Bd. Educ., 500 Park Ave., New York City, received bids for installing a heating and ventilating system in the Bryant High School on Wilbur Ave., between Academy and Radde Sts., from Gillis & Geoghegan, 537 West Bway., New York City, $154,800; E. Rutzler Co., 404 East 49th St., New York City, $159,669. Noted Dec. 21.

**N. Y., New York**—F. Begrisch and C. L. Acker, 200 Bway., will soon award the contract for a 12 story office building on 36th St. and 5th Ave. About $3,500,000. R. H. Almiroty, 46 West 46th St., Archt. and Engr.

**N. Y., New York**—The Bd. Educ., 500 Park Ave., will soon award the contract for furnishing heating and ventilating equipment in P. S. 130 on Hester and Baxter Sts. C. B. J. Snyder, Municipal Bldg., Engr.

**N. J., Newark**—The Bureau of Markets is having preliminary plans prepared for a market. About $1,300,000. F. Grad, 245 Springfield Ave., Archt. and Engr.

**Pa., Byberry**—The Hospital for Mental Diseases, c/o Dept. of Health, City Hall, Philadelphia, plans to build a hospital here. About $600,000. P. H. Johnson, 1713 Sansom St., Archt.

**Pa., Mt. Airy** (Philadelphia P. O.)—The State Armory Bd., Harrisburg, is having plans prepared for a 2 story armory. About $1,000,000. P. H. Johnson, 1713 Sansom St., Philadelphia, Archt.

**Pa., Philadelphia**—The Dept. of Health is having plans prepared for hospital buildings on 34th and Spruce Sts. About $350,000. P. H. Johnson, 1713 Sansom St., Archt.

**Pa., Pottstown**—The Bd. Educ., West and Franklin Sts., plans to build a 3 story high school including a steam heating system on Franklin St. About $300,000. J. T. Simpson & Co., 31 Clinton St., Newark, N. J., Archt. and Engr.

**Pa., Springdale**—The West Penn Blower Co., West Penn Bldg., Pittsburgh, plans to build an addition to its power plant. About $500,000. A. M. Lind, Pres. Sanderson & Porter, 52 William St., New York City, Engrs.

**Md., Baltimore**—The Washington Baltimore & Annapolis R.R. will soon receive bids for a 4 story, 60 x 60 ft. warehouse and a 1 story, 60 x 260 ft. waiting room including a steam heating system on Howard, Pratt and Eutaw Sts. About $300,000. J. J. Doyle, Genl. Mgr. Dreher, Churchman, Paul & Ford, 1424 Walnut St., Philadelphia, Pa., Archts.

**D. C., Washington**—A. L. Flint, General Pur. Officer of the Panama Canal will receive bids until April 11 for furnishing power and refrigerator equipment.

**W. Va., Charleston**—Kanawha County plans to build a 6 story, 50 x 100 ft. addition to courthouse. About $325,000. H. Ruswarre, Archt.

**W. Va., Williamson**—The Coalton Coal Corp., J. T. Jones, Cambria, Va., Purch. Agt., is in the market for a 2 bucket gravity conveyor, 800 ft. long to have a daily capacity of 500 tons., motors, etc.

**N. C., Fayetteville**—Cumberland County plans to build a 4 story court house. About $400,000. F. P. Milburn, Union Savings Bank Bldg., Archt.

**N. C., Wilkesboro**—The Superior Williams Mill Co. plans to build a factory along the Reddies River near here and develop water power to manufacture a new type of portable burr mills. About $40,000.

**S. C., Columbia**—The Chicona College plans to build dormitories. About $250,000. C. C. Wilson, Palmetto Bldg., Archt.

**S. C., Columbia**—The Security Bldg. Corp. will receive bids until March 24 for a 6 story Masonic temple on Lady St. About $250,000. James B. Urquhart, 2303 Taylor St., Archt. and Engr.

**Ala., Birmingham**—The Fifth Ave. Presbyterian Church plans to build a 120 x 140 ft. church on 5th Ave. and 18th St. North. About $250,000. Address W. M. Cosby, 3800 Cliff Rd.

**Ala., Montgomery**—The state is having plans prepared for a 3 story prison and power plant 4 mi. from here. About $700,000. Martin Lide, Woodward Bldg., Birming. Archt. and Engr.

**Tenn., Crossville**—The Crossville Light Co. plans to build a light and power plant. About $5,000.

**O., Akron**—The Bd. of Directors will receive bids until March 25 for a 10 story, 130 x 350 ft. hotel and theatre building including a steam heating system on Prospect and Market Sts., for the Akron Prospect Co., North Prospect St. About $3,000,000. J. Eberson, Steinway Hall Bldg., Chicago, Archt.

**O., Columbus**—Aquinas College, 557 Mt. Gernon Ave., c/o Rev. Father Meagher, is having plans prepared for a 3 story, 159 x 204 ft. college. About $500,000. Outcalt & Ramsey, 115 East Broad St., Archts.

**O., East Cleveland** (Cleveland P. O.)—The Euclid Superior Market Co., 5005 Euclid Ave., Cleveland, is having plans prepared for a 1 and 2 story, 154 x 210 ft. theatre and market house on Euclid and Superior Aves. About $500,000. Cavanaugh & Baer, 2725 Prospect Ave., Cleveland, Archts.

**O., Massillon**—The Masonic Temple Bldg. Co. plans to build a 4 story, 87 x 150 ft. masonic temple. About $200,000. Thayer & Johnson, 5716 Euclid Ave., Cleveland, Archts.

**O., Westerville**—The Bd. of Trustees of Otterbein University plans to build new buildings to include a women's and men's dormitory, a heating plant, etc. About $500,000.

**O., Youngstown**—Frank Leish, 224 East Boardman St., plans to build a 2 story, 70 x 140 ft. garage. About $200,000.

**Ind., Ft. Wayne**—The Mizpah Temple, Order of Masons, plans to build a shrine temple. About $300,000. Architect not selected.

**Ind., Gary**—The Bd. Educ., Harrison and 7th Aves., had plans prepared for a 2 story, 150 x 280 ft. school on 15th St. between Chase and Taft Sts. About $500,000. A. Wirt, Supt. W. B. Ittner, 911 Locust St., St. Louis, Mo., Archt.

**Ind., Indianapolis**—The Indiana Refrigerating Co., 232 South Pennsylvania St., will build a 2 story refrigerating plant. About $50,000.

**Ind., Indianapolis**—The Polar Ice & Fuel Co., 20th St. and Northwestern Ave., plans to build a 1 story, 35 x 70 ft. ice plant on West 20th St. About $40,000.

**Ind., Indianapolis**—The Tabernacle Presbyterian Church, 11th and Meriden Sts., plans to build a 2 story, 189 x 300 ft. church on East 34th St. About $200,000. J. W. C. Corbusier, Lenox Bldg., Cleveland, O., Engr.

**Ind., Linton**—The city will soon award the contract for a power plant to have a 600 kw. capacity. Two 300 kw. horizontal steam turbines, two 200 hp. water tube boilers, condensers and feed pumps will be installed in same. About $74,000. Shourds Stoner Co., 510 Tribune Bldg., Terre Haute, Engr.

**Ind., Terre Haute**—The Reservoir Improvement Co. plans to build a drainage pumping station and is in the market for two 24 in. centrifugal pumps, either steam or gas engine power, etc. About $20,000. Frank A. Kattman, 26 Beach Blk., North, Engr.

**Mich., Detroit**—C. E. Konneker, 502 Moffat Bldg., is having plans prepared for a 3 story, 132 x 145 ft. automobile sales building on Cass Ave. and Kolburn St. Power equipment for service department will be installed.

**Mich., Detroit**—The University, c/o T. W. Doran, East Jefferson Ave., plans to build a 3 story, 55 x 200 ft. school including steam heating equipment on Jefferson Ave. and Hastings St. About $200,000.

**Mich., Detroit**—T. B. Winsheimer, c/o C. W. Brandt, Archt., Kresge Bldg., is having plans prepared for a 2 story, 90 x 140 ft. theatre including steam heating and mechanical ventilation equipment, on Jefferson and Coplin Aves.

**Mich., Grand Rapids** — Robinson & Campau, Archts., will receive bids until March 21 for a 3 story tuberculosis hospital including a steam heating system for the Municipal Tuberculosis Hospital. About $400,000.

**Mich., River Rouge**—The city will soon award the contract for furnishing 4 motor driven centrifugal pumps of span impeller type. G. Jerome, 1331 Majestic Bldg., Detroit, Engr.

**Ill., Chicago**—The Chicago Theological Seminary, 5757 University Ave., plans to build a group of buildings including a library, hall and dormitory. A steam heating system will be installed in same. About $500,000. Riddle & Riddle, 122 South Michigan Ave., Archts.

**Ill., Chicago**—The Logan Sq. Masonic Temple Assn., c/o A. J. Donavon, 38 South Dearborn St., is having plans prepared for a 4 story, 100 x 120 ft. masonic temple including a steam heating system on Albany Ave. and Kedzie Bl. About $300,000. C. Hatzfeld, 7 South Dearborn St., Archt.

**Ill., Chicago**—The Peoples Trust & Savings Bank, 30 North Michigan Ave., plans to build a 6 story, 50 x 150 ft. addition to office building including extension to present high pressure heating plant on Michigan Ave. and Randolph St. About $400,000. J. Hunt, Archt.

**Ill., Chicago**—The South Side Masonic Temple Assn., 624 West 71st St., is having plans prepared for a 4 story, 105 x 120 ft. Masonic temple on West 64th and Green Sts. About $375,000. C. Hatzfeld, 7 South Dearborn St., Archt.

**Ill., Chicago**—The United Assn. of Plumbers & Steam Fitters, 800 North Clark St., is having plans prepared for remodeling a 3 story, 50 x 150 ft. building on Elm and Dearborn Sts. About $400,000. W. W. Ahlschlager, 65 East Huron St., Archt.

**Ill., Oak Park**—Ralph C. Harris, Archt., 190 North State St., Chicago, will soon award the contract for a 3 story, 150 x 300 ft. apartment house including a steam heating system on Euclid Ave. and Pleasant St. About $250,000. Owner's name withheld.

**Ill., Rock Island**—W. S. Armstrong, Engr., 127 North Dearborn St., Chicago, is preparing plans for a 4 story, 102 x 120 ft. hotel and store building. About $300,000. Owner's name withheld.

**Wis., Cedarburg**—The E. & W. Mfg. Co., 325 Oregon St., Milwaukee, plans to build a 1 story, 60 x 120 ft. factory including individual motors. About $50,000. Architect not selected.

**Wis., Kenosha**—The Blomer Ice Cream Co., 1502 North Ave., Milwaukee, will soon award the contract for a 1 story, 40 x 60 ft. ice cream plant and a 26 x 30 ft. garage on Erie St. An ice machine and compressor will be installed in same. About $45,000 C. Stehling Co., 401 4th St., Milwaukee, Archt. and Engr.

**Wis., Park Falls**—The city voted Feb. 21 to issue $85,000 bonds to extend water mains, build addition to pumping station, etc. W. F. Reichardt, Watertown, Engr.

**Wis., Racine**—The New York Market Co., 1015 6th St., will receive bids until March 25 for a 3 story, 96 x 100 ft. sausage factory. Special machinery and motors will be installed in same. Packers Architectural Eng. Co., 431 South Dearborn St., Chicago, Ill., Archt and Engr.

**Wis., Rhinelander**—The city is having plans prepared for a pumping station, distributing system, etc. About $135,000. Pearse Greeley & Hansen, 39 West Adams St., Chicago, Ill., Engrs.

**Ia., Sioux City**—The Scottish Rite Templars, c/o J. R. Carver, 410 Pierce St., will soon award the contract for a 4 story, 150 x 315 ft. Shrine temple including a high pressure steam heating system on 12th and Jackson Sts. About $1,500,000. Harold Holmes, 151 East Chicago Ave., Chicago, Archt.

**Minn., Duluth**—The St. Luke Hospital Assn., 901 East First St., plans to build a 5 story, 75 x 125 ft. addition to its hospital including a steam heating system on 1st St. and 9th Ave., East. About $475,000. McKin, Mead & White, 101 Park Ave., New York City, Archts. and Engrs.

**Minn., Minneapolis**—The Minneapolis Building Co., c/o G. Mowry, 703 3rd Ave., had plans prepared for a 15 story, 99 x 157 ft. hotel including a steam heating system on 2nd Ave. South and 4th St. About $1,000,000. Bertrand & Chamberlain, Northwestern Bank Bldg., Archts.

**Minn., Minneapolis**—The Normandie Hotel Assn., c/o R. J. Meland, 1401 6th St., S. E., plans to build a 12 story hotel including a steam heating system. About $1,500,000.

**Minn., Savage**—The Masonic Home Corp., plans to build a masonic home to include a hospital along the Minnesota River here. About $500,000. Stewart Gamble, 901 Hennepin Ave., Minneapolis, Pres.

**Minn., St. Cloud**—The city had preliminary plans prepared for a steam electric power plant to have a 5,000 kw. capacity. About $750,000. A. W. Buckman, Clk. L. P. Wolff, 1001 Guardian Life Bldg., St. Paul, Engr.

**Minn., St. Paul**—H. D. Lock, 30 North La Salle St., Chicago, will soon award the contract for a 3 or 4 story, 75 x 90 ft. post office building including a steam heating system on 3rd and Sibley Sts. About $750,000. U. S. Government, Lessee.

**Kan., Lawrence**—The Bd. Educ. is having plans prepared for a 2 story high school. About $500,000. I. C. Stevenson, Supt. W. B. Ittner, 915 Locust St., St. Louis, Mo., Archt.

**Wyo., Cheyenne**—Dubois & Goodrich, Archts., will receive bids about May 1 for a 4½ story temple, for the Scottish Rite Consistory. About $500,000.

**Mo., Brookfield**—The city is having plans prepared for a new water supply system including a reservoir, pumping station, etc. About $140,000. E. E. Harper, 3031 Park Ave., Kansas City, Engr.

**Mo., Fulton**—The city plans an election to be held April 4 to vote on $75,000 bonds for an addition to power plant which will include 1 complete unit of steam power and 1 complete generating unit. E. F. Baker, City Hall, Engr.

**Mo., Fulton**—The Fulton State Hospital plans to build a power house. About $40,000. M. O. Biggs, Supt.

**Mo., St. Louis**—The Sisters of St. Mary, 1536 Papin St., will soon award the contract for a 7 story, 160 x 280 ft. hospital on Belleview Ave. and Clayton Rd. About $1,000,000. A. B. Groves, Stock Exch. Bldg., Archt.

**Mo., Warrensburg**—The city will soon receive bids for furnishing engines, generators, switchboard, water tube boilers and stokers and 2,450 k.v.a. units, etc. F. L. Wilcox, Chemical Bldg., St. Louis, Engr.

**Tex., Dallas**—The Dallas Scottish Rite Cathedral Assn., is having sketches prepared for a 3 story addition to its lodge building. About $750,000. H. M. Greene Co., North Texas Bldg., Archt.

**Okla., Mountain View**—The city will soon award the contract for an addition to power plant. A motor generator set and two 100 hp. boilers will be installed in same. About $30,000. T. E. Gibbons, clk. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, Engr. Noted March 9.

**Okla., Oklahoma City**—The Masonic Order, 400 North Bway., is having plans prepared for a 6 story masonic temple on 6th and Robinson Sts. About $1,000,000. Bailey & Alden, 1207 Colcord Bldg., Archts.

**Okla., Weleetka**—The city plans an election to vote on bonds to purchase the water, light and ice plants, build extensions and install equipment. V. V. Long & Co., Colcord Bldg., Oklahoma City, Engrs.

**Utah, Price**—The Carbon Water, Land & Power Co. is having plans prepared for the reconstruction of Mammoth dam. About $125,000. W. W. Jones, Engr.

**N. S., Trenton**—The Nova Scotia Steel & Coal Co. will soon award the contract for the construction of a machine shop, boiler house and forge and is in the market for equipment for same.

**Que., Montreal**—The Mount Royal Hotel will soon award the contract for a 10 story hotel on Peal St. About $1,750,000. Ross & McDonald, 1 Belmont St., Archts. and Engrs.

**Que., Montreal**—The Water Bd. plans to expend $500,000 to build pumping station and install equipment at the Notre Dame de Grace Ward. J. Baillets, Chief Engr.

**Ont., Brockville**—The Town Council will soon receive bids for an addition to the waterworks pumping station. One Diesel engine, generator motor and pump will be installed in same. About $45,000. J. B. McRea, Booth Bldg., Sparks St., Ottawa, Engr.

**Ont., Gorrie**—The Town Council plans to build a hydro electric system and is in the market for transformers and all general equipment. About $10,000. C. E. Walker, Engr.

**Ont., Hamilton**—The Hydro Electric Comn. of Ontario, University Ave., Toronto, plans to build a 110,000 volt station. A 110,000 volt line will be carried to the eastern city limits. W. Ellis, Chn. F. A. Gakey, Chief Engr.

**Ont., Hamilton**—The Winchester Repeating Arms Co., 275 Winchester Ave., New Haven, Conn., plans to build a firearms factory here. About $500,000. Architect not selected.

**Ont., London**—The City Council is in the market for two electrically driven pumps for pumping sewage. About $15,000. H. A. Brazier, Engr.

**Ont., Merlin**—The Town Council plans to have estimates made for installing a hydro electric plant for lighting and power distribution.

**Ont., Ottawa**—The Famous Players Canadian Corp., Temple Bldg., Toronto, will soon receive bids for a 1 and 2 story, motion picture theatre including a vacuum steam heating system with electric driven mechanical ventilation system. About $350,000. T. W. Lamb, 269 Victoria St., Toronto, Archt.

**Ont., Ottawa**—Milkon & Burgess, Archts., 209 Sparks St., are preparing plans for an artificial ice skating rink on King Edward Ave. Artificial ice equipment will be installed in same. About $325,000. Owner's name withheld.

**Ont., Peterborough**—S. R. Armstrong, Secy. of the Pub. Utilities Comn., will receive bids until April 1 for a 6,000,000 gal. mechanical gravity filter plant. 2,000,000 gal. reservoir and electrically operated centrifugal low lift pumps, to have a daily capacity of 6,000,000 gal. About $350,000. R. L. Dobbin, Engr.

**Ont., Toronto**—The Westminister Presbyterian Church, Bloor St., East Toronto, plans to build a 1 story church on Bloor St. A hot air heating system will probably be installed in same. About $250,000.

## CONTRACTS AWARDED

**Mass., Brockton**—The Brockton Realty Co., 17 Milk St., Boston, has awarded the contract for a 2 story, 150 x 200 ft. store and office building including a steam heating system on Main St., to G. Howard & Sons Co., Inc., 153 Main St. About $250,000.

**N. Y., Brooklyn**—Shermerhorn Constr. Co., 80 Bway., New York City, has awarded the contract for a 7 story hotel including a steam heating system on Schermerhorn St., to the Edward Corning Co., 145 East 45th St., New York City. About $250,000.

**N. Y., New York**—The Mohawk Holding Co., c/o W. Haefeli, Archt., 229 West 42nd St., has awarded the contract for four apartment houses including steam heating systems on Vermilyea Ave., to L. A. Scott, 229 West 42nd St. About $600,000.

**N. J., Trenton**—The Y. M. C. A. has awarded the contract for a 5 story, 140 x 185 ft. Y. M. C. A. home, to Karno Smith Co., Broad St. Bank, at $459,000.

**Pa., Scranton**—Deleware, Lackawanna & Western Mine Dept., has awarded the contract for a 3 story, 23 x 72 ft. switch building at the Hampton Power plant here, to Sykes & Sons, at $48,000. This project is in connection with a 60,000 volt line from Nanticoke Power plant.

**O., Baltimore**—The Fairfield Paper Co. has awarded the contract for a 2 story, 90 x 790 ft. factory and warehouse, to H. K. Ferguson Co., 6523 Euclid Ave., Cleveland. About $400,000.

**O., Cleveland**—The Bd. Educ., East 6th St. and Rockwell Ave., has awarded the contract for the installation of a heating system in the proposed school on Euclid Ave. near Burges Rd., to the Amer. Piping & Equipment Co., Schofield Bldg., at $43,416. Noted March 9.

**O., Cleveland**—The city has awarded the contract for installing a heating and ventilation system in the proposed public hall, to the Chappell Warren Co., 1836 St. Clair Ave., at $375,536. Noted Feb. 22.

**Mich., Lansing**—The state has awarded the contract for a 6 story office building including steam heating equipment, to W. E. Wood & Co., Ford Bldg., Detroit. About $1,100,000.

**Mich., Munising**—The Township School Dist. has awarded the contract for a high school, to the Foster Constr. Co., 114 Grand Ave., Milwaukee, Wis. About $300,000.

**Ill., Chicago**—The Union Liberty Co., 1272 Milwaukee Ave., has awarded the contract for a 15 story, 60 x 80 ft. office building including a high pressure steam heating system at 8-16 North Clark St., to the Paschen Bros., 111 West Washington St. About $1,000,000. Noted Dec. 21.

**Wis., Waukesha**—The Waukesha Ice Cream Co., 208 Charles St., has awarded the contract for a 2 story, 40 x 60 ft. factory including ice cream machinery and refrigerating equipment, on Arcadian Ave., to the Crary Brokerage Co., 331 West Main St. About $40,000.

**Ia., Cedar Rapids**—The city has awarded the contract for repairs and improvements to the water department pumping station on 2nd St. North and Division Ave., to the Loomis Bros., 319 3rd St., South, at $30,000.

**Minn., North Branch**—The city has awarded the contract for a waterworks system including a deep well pump and tower tank, to the Hedberg Boice Co., 2208½ West 2nd St., Duluth, at $33,174. Noted March 1.

**Kan., Hutchinson**—The Grover Starr Product Co. has awarded the contract for a 2 story, 112 x 170 ft. produce warehouse including a modern ventilating and cold storage plant on 4th Ave. and Washington St., to the Parson Constr. Co., 616 Keeline Bldg., Omaha, Neb., at $125,000.

**Neb., Schuyler**—The Colfax Co. has awarded the contract for a 4 story, 70 x 90 ft. court house, to R. O. Stake, Lincoln, at $148,500.

**Col., Denver**—The Colorado Agricultural College, Ft. Collins, has awarded the contract for installing a heating system in the proposed woman's club building, to Joseph Pfeiffer, 1140 California St., Denver, at $11,489.